NOTES AND MEMORANDA

ON THE

EASTERN JUMNA, OR DOAB CANAL,

AND ON THE

WATER COURSES IN THE DEYRA DOON.

BY

COLONEL SIR P. T. CAUTLEY, K.C.B.

LATE SUPERINTENDENT OF CANALS, N. W. P.

ROORKEE:

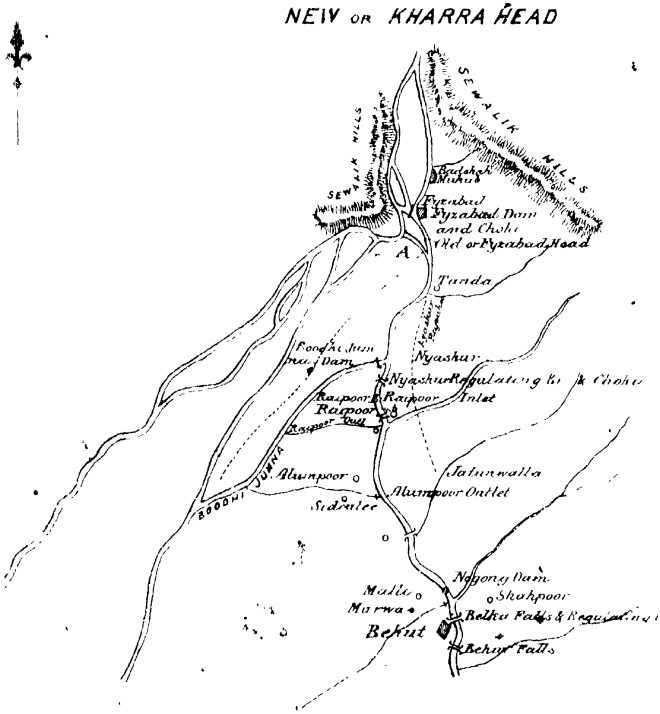
PRINTED AT THE THOMASON COLLEGE PRESS

1861.

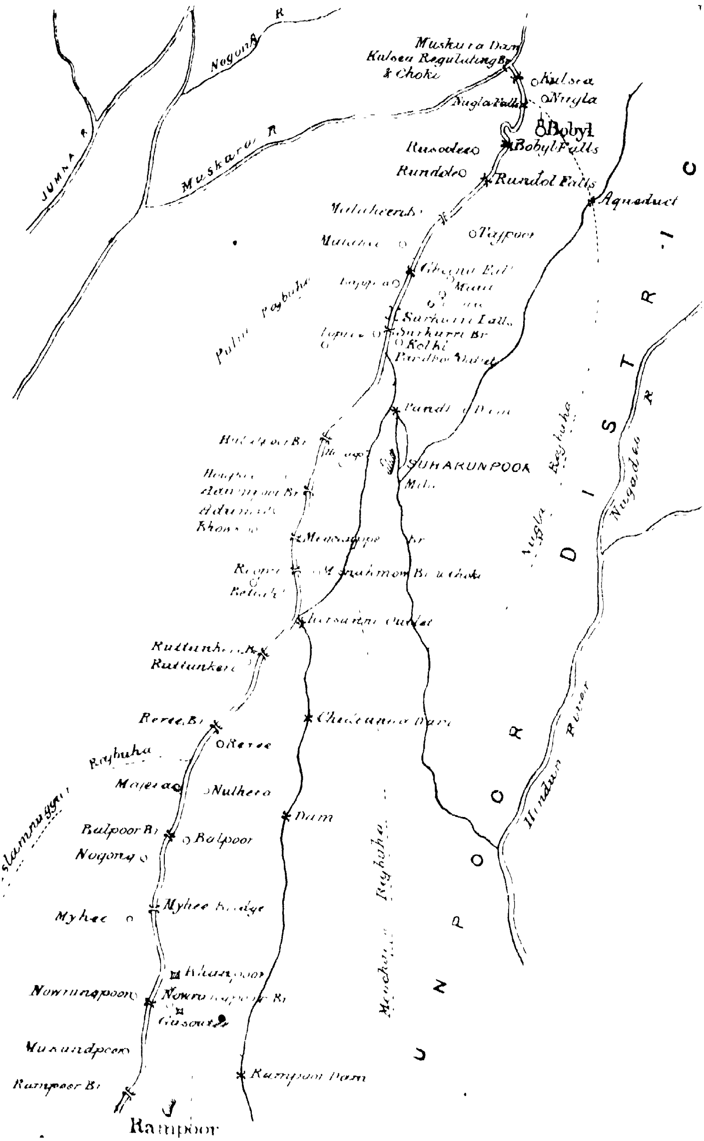
Sketch of the DOOAB CANAL AND WORKS.

British Miles

Sheet 1.

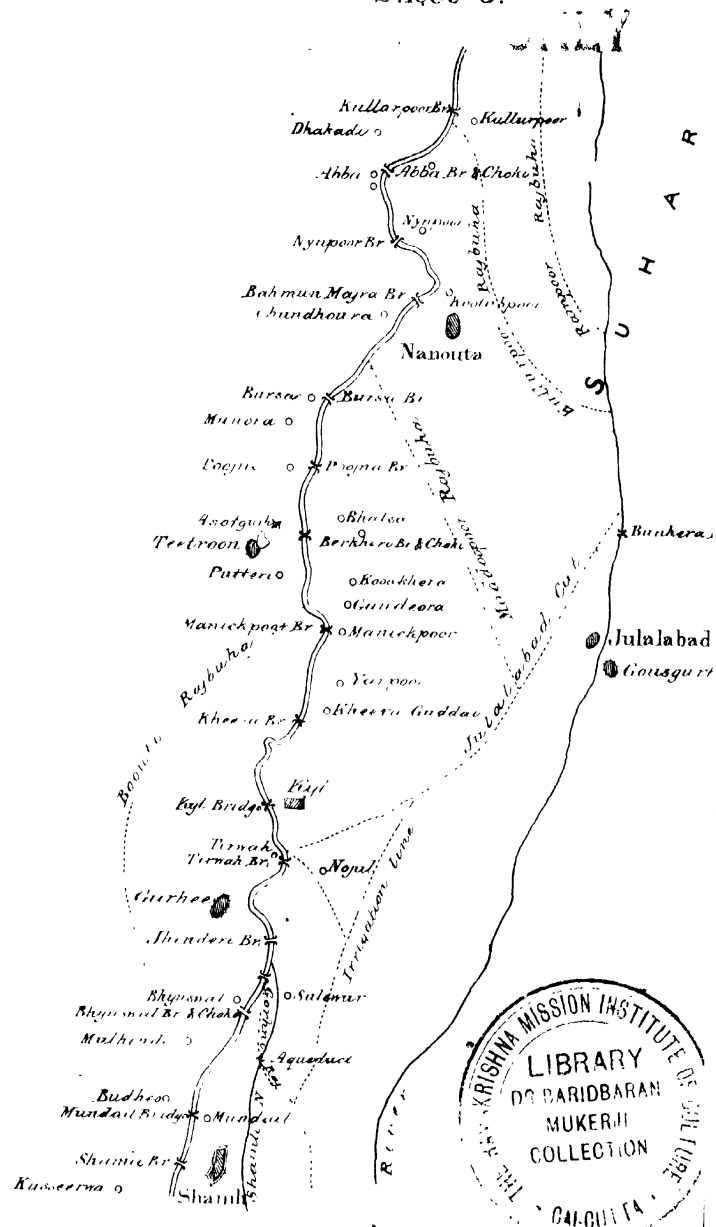


Sheet 2.

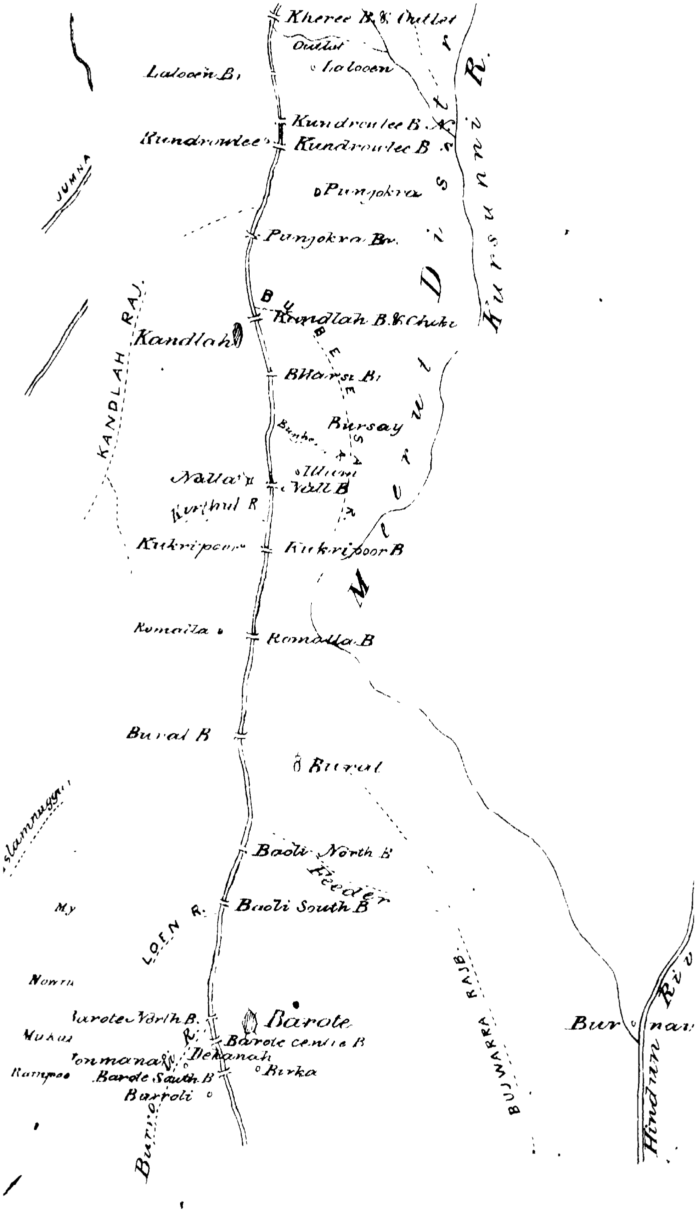


Muskura Dam
Kulsea Regulating Br
& Choki
Kulsea
Nugla
Bobyl
Bobyl Falls
Rundol Falls
Aqueduct
Rundol
Tajpoor
Surkurri Br
Kolhi
SUHARUNPOOR
Muskara R
Nogong R
JUMNA R
Rerce Br
Rerce
Rajbuha
Nulhera
Balpoor Br
Balpoor
Myhee
Myhee Bridge
Nowrungpoor
Rampoor Br
Rampoor Dam
Rampoor
Hindun River
Nugadeo

Sheet 3.

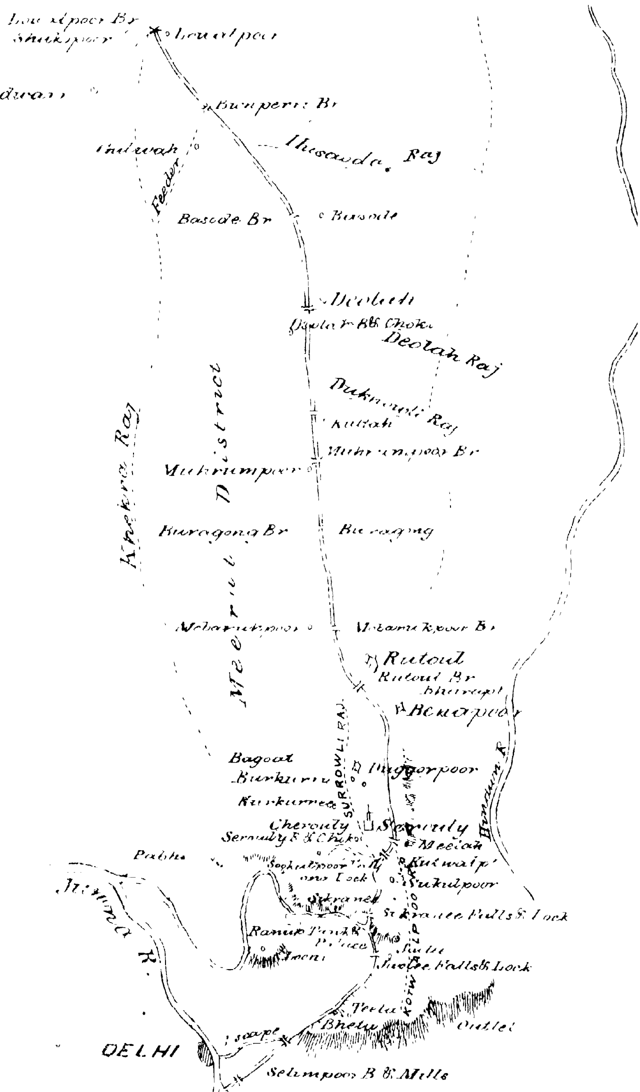


Sheet 4



Kheree B & Outlet
Outlet
Lalooen
Lalooen B
Kundroulee B
Kundroulee
Kundroulee B
Punjokra
Punjokra Br.
JUMNA
Kurrsunni R.
Doab Canal
KANDLAH RAJ
Kandlah
Kandlah B & Chuki
BUBEE
BHarsi B
Bursay
Nalla
Nall B
Kirthul R
Kukripoor
Kukripoor B
Meerut
Romaila
Romalla B
Bural B
Bural
Baoli North B
Feeder
Baoli South B
LOEN R.
My
Barote North B.
Barote
Barote centre B
Dekanah
Birka
Barde South B
Barroli
BUJWARRA RAJB.
Bur
Hindun Riv

Sheet 5.



Bunperi Br
Basode Br
Deolah Raj
Meerut District
Kuragong Br
Rutoul
Rutoul Br
Bagput
SURROWLI RAJ
DELHI
Selimpoor B & Mills

DOAB CANAL.

On my departure for Europe, after having been connected with the Doab Canal for twenty years, it has been suggested to me that an account of the different works, and an outline of the views upon which the Canal has been conducted, would be useful to my successors, and satisfactory to the Government, the following Memoir, therefore, is intended as a general sketch of the earlier periods of the Canal, with a practical detail of works and operations, interspersed with such remarks as have from time to time suggested themselves to me.

2. It does not appear certain under whose reign, during the Moghul Dynasty, this Canal was originally projected, whether in that of Shah Jehan, or Muhummud Shah*—in later years, however, it is said to have been partially restored by the Rohilla Chief Zabitha Khan, (son of Nujab od dowla, an Afghan Rohilla, well known as the guardian of Jewan Eukht, an Emperor, of Abdalla's creation in 1761. Zabitha Khan died in 1784-85—Nujab od dowla's territory included the Suharunpoor District—at one time, however, he appears to have held Sirhind as well as the Districts bordering on Delhi,) who succeeded in bringing a stream of water from the Jumna to Gousghur, a fortified camp and one of his principal residences in the Suharunpoor District; there are traditions of serious damage having been caused to the Towns of Behut and

* Shah Jehan reigned from 1628 to 1659, Muhummud Shah from 1718 to 1748.

Suharunpoor by the opening of this Canal by Zabitha Khan, and it is probable that both in his case, and in that of the original projector, the difficulties of maintaining a passage over so many mountain torrents led to the works being abandoned. It is, however, perfectly clear, that no great quantity of water could ever have been allowed to run for any lengthened period of time, the excessive slope of country between the Nogong and Muskurra Rivers would have led to a retrogression of levels fatal to the direction which the former now holds—no masonry works of any description were in existence, and although traces of excavation were found in the Meerut District, it may be fairly doubted whether the Canal water ever reached so distant a point. A Royal preserve at Ranup, a place on the left bank of the Jumna, and near to and opposite the City of Delhi, is said to have received its supply of water from the Doab Canal—and the Hunting Palace of the Emperor, denominated "Badshah-mahul,"* situated in the forests

* When I first visited Badshah-mahul in 1826, the buildings and enclosure, of about 350 yards square, were covered with an almost impenetrable jungle—the roofs of the large rooms and apartments which had rested on timber had fallen in, and their floors were covered with the ruins not only of the roof and walls, but also of the remains of the ornamental stone work, which, ever since the place has been deserted, had been quarried and cut up by the natives—in clearing away these ruins from two of the largest rooms which had evidently been the 'Dewan-i-khas' of two sets of palaces—one of which was situated on the north and the other on the south face of the quadrangle—a good deal of marble was found, which had, owing to the thickness of the debris in the flooring, escaped the observation and cupidity of plunderers—the marble consisted of reservoirs, which had formerly been connected with fountains, these were carefully removed, and are now in the store rooms at Manukmow—the largest and handsomest reservoir with its attendant slabs, I intended for the Botanical Garden at Suharunpoor—the smallest for the Fountain on the Rajpoor Water Course attached to the Goorkha lines at Deyra. The remains of the Aqueduct which supplied the palace fountains is distinctly traceable from the Kharra Head, although, unless the levels or direction of the Jumna have very much altered, it is not very clear in what manner the supply was obtained—this Aqueduct looks in the present time like a mound or raised bank, it crossed the Gayjra Row by a Masonry Aqueduct, some of the piers of which are now standing—the water appears to have been conducted from pier to pier in a wooden channel, as there are no appearances of arches.

north of Nyabun, was undoubtedly built either on an old branch of the Jumna, through which the Canal stream was brought, or on an excavated channel made for the purposes of the Canal.

3. In consequence of a recommendation from the Board of Commissioners, dated 7th October 1808, based on the Reports of Col. Kyd, Chief Engineer, Lieut. Tod, of the 25th Regiment Native Infantry, was deputed to the survey of the Doab Canal; this survey was, I believe, completed in 1810; in 1814, Major J. A. Hodgson, when carrying on a geographical survey in the Doab, entered very minutely into the examination of the old line between the Jumna River and Suharunpoor—but from this date up to 1822, no further steps appear to have been taken by the British Government.

4. In 1822, Lieut. Debude, of the Engineers, was appointed to survey and report upon the practicability of opening the Doab Canal—and in the following year Capt. Robt. Smith, of the same Corps, was appointed Superintendent. Capt. Smith's Estimate of the probable expense of opening the Canal "from the proposed new head near Fyzabad, to its re-union with the Jumna near Looni opposite to Delhi," is dated 25th May 1823, and amounted to Rupees 2,03,633-3-9. Excavation was commenced at the close of 1823.

5. The line taken up by the original projectors passed centrically over the high land between the Hindun and its tributaries and the Jumna River, although obliterated at some points, the marks of the old excavated Channel were sufficiently connected to establish the true bearing of the ancient Canal—the courses of

---

The branch of the Jumna has formerly made a set upon the N. W. angle of the quadrangle, and thrown down a vast quantity of building and long lines of revetment,—these masses are now lying in the bed of the river built almost entirely of round boulders with cement, and bearing the appearance of a natural Conglomerate Rock: one proof at least, that boulder masonry is not to be despised.

Rivers had been taken advantage of as much as possible, and generally speaking, great skill appears to have been exhibited in selecting a course most favorable to the purposes of irrigation. It is probable that when the Canal was originally dug, the head was taken from the point B, in the Map, that the stream passed under the Palace, or Badshah-mahul, and entered the Boodhi Jumna above the village of Tanda, from thence down the bed of the latter River to a point opposite Nyashur,—at this point the true or certain line of artificial excavation commences, in a cut connecting the Boodhi Jumna, with the Raipoor River, down the course of which the stream was carried in a south-easterly direction for about 2 miles, the Raipoor River at this point takes a direction to the south-west, but the Canal continues its south-easterly course over the high land, passing the Jaton Wala drainage, and the Nogong River, beyond which at the distance of half a mile it terminated at the head of a ravine or hollow called the Behut Khala; through this ravine the stream took its course until its junction with the Muskurra, a mountain torrent of considerable magnitude; but as in the case of the Raipoor, Jaton Wala and Nogong lines of drainage, only charged with water during freshes in the rainy months, their beds being perfectly dry at other periods of the year: down the course of the Muskurra the Canal passed for about 4000 feet until its approach to the village of Kulsea; here the excavation commenced again on the high land passing to the west of Suharunpoor, and terminating at the head of the Shamli Nulla immediately north of the village of Abba. From this point the Canal appears to have continued along the tortuous line of the Shamli Nulla for about 24 miles, until its approach to the village of Bynswal, in the Muzuffurnuggur District,—here the Nulla took a sharp bend off to the east, and the Canal was conducted in a southerly direction passing to the west of Shamli, east of Kandla and west of Barote; after passing the latter place, the line was inclined somewhat to the south-east,

until it arrived at Deola, from whence it returned to its southerly direction. About 12 miles below Deola the excavation terminated in the Sikrani Nulla, down which the stream must have been conducted to Ranup and the Jumna.

6. Colonel Smith's line was the same with some trifling modifications, the head, instead of being at B, was established at A, and instead of letting the tail water escape into the Jumna down the Sikrani Nulla, a straight cut was made from the village of Gokulpoor to Selimpoor on the Jumna, leaving the Sikrani as an escape for floods during the rains, or superfluous water at other seasons. The Canal between Abba and Bynswal was maintained in its old course down the Shamli Nulla, the tortuosities of which were, in the minor details, occasionally corrected.

7. Early in 1825 I joined the Canal as an Assistant to Capt. Robt. Smith. At that time excavation was in progress from Kandla downwards; a portion of the Canal Channel near Behut and Kulsea had been excavated, and three cuts had been made at the villages of Kalowala, Dowlakooa, and Ullooni, to throw the waters of the Muskurra into the Hindun River. No masonry works of any description had been commenced at this period.

8. On the 3d of January 1830, the whole of the excavation being completed, the masonry works being in a sufficient state of advancement to admit of the opening of the Canal, and the head of the Boodhi Jumna having been prepared for the admission of the Canal supply, the Doab Canal was opened in the presence of Colonel Colvin, Superintendent of Canals, and the Civil Officers of the District, Captain Robt. Smith's health not having permitted him to remain to witness this satisfactory termination to his labors. The Canal water, which consisted of a small supply, reached the Jumna at Selimpoor on the 14th of January, having been about 11½ days in progress, at a rate of little less than half a mile an hour.

9. On Colonel (then Captain) Smith's departure, I was allowed to remain in charge of the Works until April 1831, when I

was permanently appointed by Lord W. Bentinck to the superintendency, with Lieutenant Robert Napier, of the Engineers, as Assistant.

10. The soil that constitutes the Canal bed may be divided into four sections.

1*st*.—From the Jumna at the head, to a point opposite Allumpoor, in the Raipoor Nulla, *shingle* or *stone boulders* decreasing in size on the approach to Allumpoor.

2*nd*.—From Allumpoor to Surkurri *sand*, with beds of clay here and there, but generally speaking the bed on this line may be described as *sand*.

3*rd*.—From Surkurri to Jaoli *clay* at some places mixed with kunkur.

4*th*.—From Jaoli to the tail of the Canal at Selimpoor *sand*. At a few points the soil is impregnated with a salt, which renders it bad for embankments,—this is particularly observable near Khera Gudai, Bynswal, and Selimpoor—but the evil is confined to short distances, and is of no material consequence.

11. It will be observed that sections 2 and 4 of the above description of soil, show that the Canal bed from Allumpoor to Surkurri and from Jaoli to Selimpoor, consisted of sand, the one being in the northern and the other in the southern region of the Canal —in both of these regions there is a considerable fall or step in the surface of the country, in the 1st case depending on the proximity to the Hills, and in the 2nd on its leaving the high land of the Doab and falling into the Khadir or low land of the Jumna River

12. Immediately after the water was admitted into the Canal the effects of a rapid current running over a sandy bed displayed themselves in rapids forming at different points upon these two sections; south of the Belka, Ghoonna, Jaoli, and Selimpoor Bridges, these were most conspicuous; beds of clay exposed by the wear of the current acted as checks in delaying the evil which was evidently

in store for the Bridges at Kulsea, Rundole and Sookulpoor, but the four Bridges first mentioned required immediate protection. On the 20th January a fall of six perpendicular feet had reached the flooring of the Belka Bridge—a similar fall had approached within 500 feet of that at Ghoonna, and the Selimpoor and Jaoli Bridges, which were nearly in a similar predicament, were fortunately opposed to so small a body of water, that no particular danger could be anticipated; at the Belka and Ghoonna Bridges the means which I adopted for their protection were in the establishment of rafts of timber strongly bound together; these rafts were picketed upon the rapid, with lines of piling on each flank; at Ghoonna this plan was most effectual, but the rapid retrogression of levels upon the Belka Bridge rendered every attempt at saving the work ineffectual.

13. The plan which I proposed for remedying the evil as far as was immediately and urgently required, was by constructing falls or descents of masonry, consisting of one chamber of 20, and a second of 15 feet wide, to be used for the purposes of lockage, scope being left for the construction of another 15 feet chamber on the other side of the larger opening so as to give uniformity to the design. These masonry descents were to be attached to Bridges. Between each separate set of falls the bed of the Canal was to be reduced to one uniform level of 17.6 inches per mile. In conformity with this proposed arrangement, bills and estimates were submitted for the following works in the 1st section:

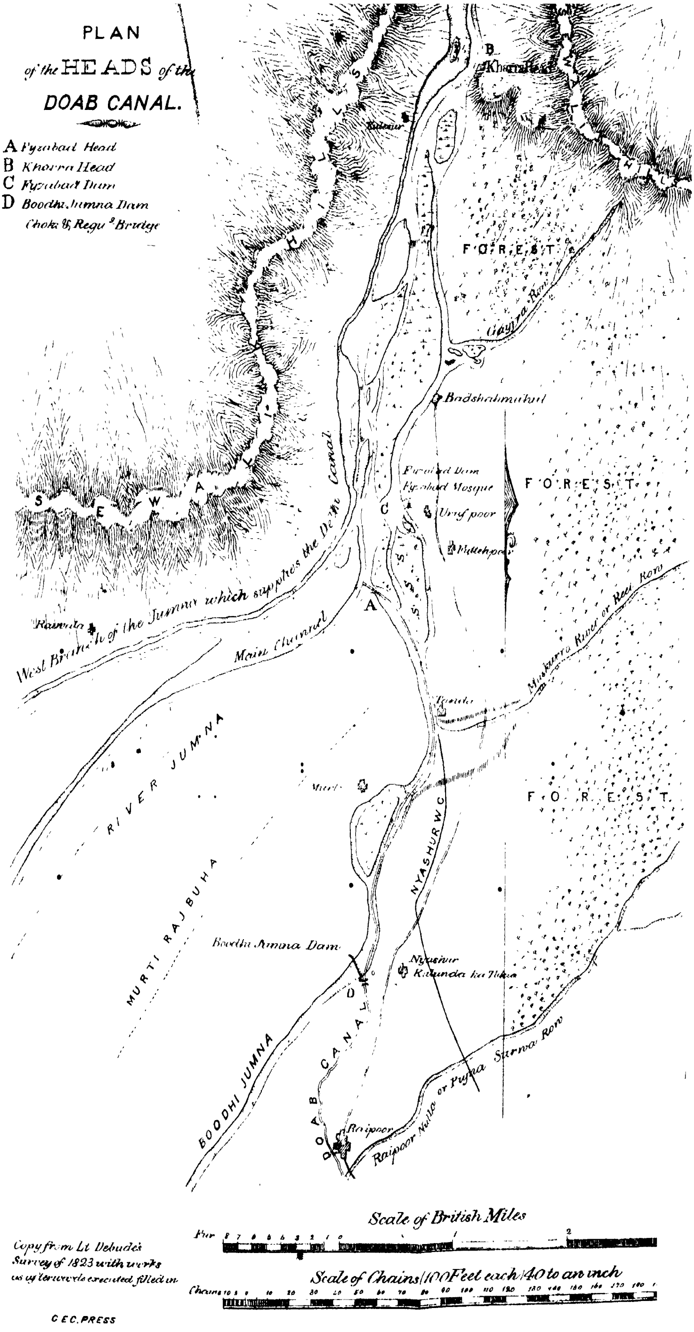
Bridge and Falls at Belka, ... 15 ft.
Falls at Rundole, ... 7½
Falls at Ghoonna, ... 7½
Two intermediate Bridges and falls at Nugla and Bobyl of 8 feet each.

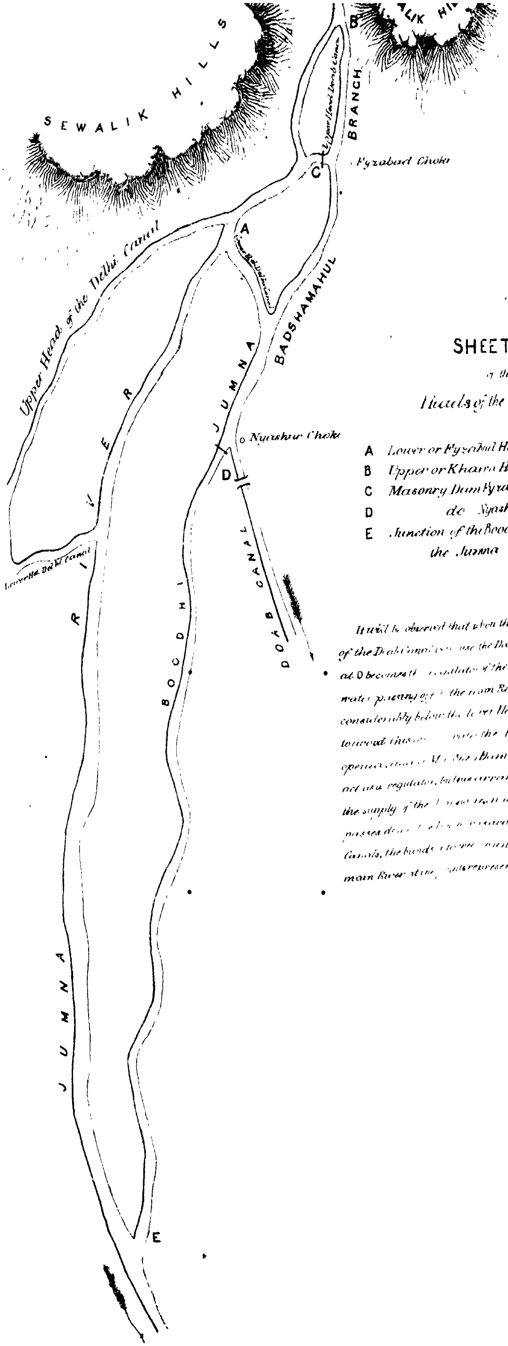
These falls were to consist of two chambers, one of 20 and the other of 15 feet in width. On the second section Falls and

Bridges were authorized at Sookulpoor, Jaoli and Selimpoor, with intermediate falls at Sikrani. At Selimpoor the fall consisting of one chamber of 15 feet, was connected with a plan of four corn mills. At the four other places the falls were projected in two chambers of 15 feet in width each, one of the chambers to be ready for the adaptation of lock gates, when such might be considered advisable. I can only recur to the anxiety and care of the period when these works were under construction—to the difficulties that were experienced in contending against these rapids, and in maintaining the supply of water in the Canal, under the deposits of silt hourly forming in the central regions, requiring constant raising of embankments on extended lines, to look with satisfaction at the results, as shewn by the gradual and annual increase of Canal Revenue, and the success which attended the construction of the works above referred to. In my "Report on the levels of the Doab Canal," (*vide* Appendix A.) dated 1st April 1837, and in the sheets of Sections, (*vide* Appendix B.) full information will be found both on points regarding the levels, and to the state of the centre divisions owing to the deposits of silt. Since the period of submitting that Report an additional 15 feet chamber has been constructed at each of the falls in the northern region, 5 other falls or descents of 4 feet each have been built south of Ghoonna, at the following places, viz. Surkurri, Hulalpoor, Mekchupper, Reeree and Balpoor, and the whole of these works as well as those formerly constructed have been adapted to lockage.

The deposits of silt have entirely disappeared on the whole line as far south as the falls at Balpoor and at the Bridges at Myhi, Nowrungpoor and Rampoor, which are immediately south of Balpoor, a satisfactory although gradual decrease is distinctly perceptible.

14. With this general sketch of the early part of our operations, I shall now proceed to a detail of the different works com-


PLAN
of the HEADS of the
DOAB CANAL.
A Fyzabad Head
B Khorra Head
C Fyzabad Dam
D Boodhi Jumna Dam
Choki & Regu. Bridge
B
Khorra Head
S
H
I
L
L
S
W
A
L
I
K
H
S
E
W
A
L
I
K
FOREST
Gayyra Row
Badshahmuhul
Fyzabad Dam
Fyzabad Mosque
C
Urufpoor
Futtehpoor
FOREST
West Branch of the Jumna which supplies the Delhi Canal
Raiunda
A
Main Channel
Muskurra River or Reel Row
Tanda
RIVER JUMNA
Mirdi
FOREST
NYASHUR W.C.
MURTI RAJBUHA
Boodhi Jumna Dam
Nyashur
Kalunda ka Tibba
D
BOODHI JUMNA
DOAB CANAL
Raipoor
Raipoor Nulla or Pyna Surna Row
Scale of British Miles
Fur. 8 7 6 5 4 3 2 1 0
1
2
Scale of Chains (100 Feet each) 40 to an inch
Chains 10 5 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
Copy from Lt. Debude's
Survey of 1823 with works
as afterwards executed filled in.
C.E.C. PRESS



SHEET No. 2

of the

Heads of the Doab Canal

A Lower or Fyzabad Head Doab Canal
B Upper or Khara Head do
C Masonry Dam Fyzabad
D do Nyashur
E Junction of the Boodhi Jumna with the Jumna

It will be observed that when the Lower or Fyzabad Head of the Doab Canal [illegible] use the Dam on the Boodhi Jumna at D becomes the [illegible] of the supply, the surplus water passing off [illegible] the main River at the point E, considerably below the Lower Head of the Delhi Canal [illegible] this [illegible] the Khara Head at B was opened [illegible] the Dam at C was built so as to act as a regulator, by this arrangement the whole of the supply of the [illegible] that portion which passes [illegible] available for the Delhi Canals, the bunds [illegible] are thrown over the main River [illegible] are represented by the dotted lines

mencing with those from the Canal Head to the Nyashur Choki, or on that portion of country represented in the accompanying Map (Survey of Lieutenant Debude, 1823,) sheet No. 1.

15. The Jumna River, at the period when Lieutenant Debude made this survey, appears to have taken a direction very similar to that which it assumed after the rains of 1844, previously to which the main stream on its approach to Kelsur kept to the right bank close under the village, leaving a smaller one on the opposite, or on that side where the main stream run in 1823. This return to its old course has tended very materially to facilitate the maintenance of the Doab Canal supply, and to reduce the expense of the operations annually required for this maintenance; the head of supply upon which the Canal chiefly rests being at B, or as it is denominated the Kharra, in opposition to that at A, which is called the Fyzabad head.

Boodhi Jumna Head, and reasons for taking possession of the Badshah-mahul or Kharra head also.

16. In 1834 a rapid in the Jumna at A, from the head of which the supply was taken, had retrograded to such a degree that the expense and delay of pushing out a spur from the shoulder A, so as to reach the top of the rapid, and thereby gain the supply, were so great, that it was determined to take possession of the Badshah-mahul branch, and the head which has been described as that used by the original projector at B. This work was executed in 1834 at an expense of about 2,205 Rupees—it merely consisted of cutting through a bed of shingle at the head of the branch at B, and constructing a bund at C, so as to prevent the water from returning to its parent stream opposite Fyzabad. It was by no means intended that the Fyzabad head should be deserted in consequence of this arrangement, but that in the event of either one or the other requiring very heavy repair, such repair might be effected without interfering with the Canal supply,

by using that one which at the close of the rains was most available. In years of drought, however, when the demand for water is great, it is very desirable that the Kharra head should be used, so that the arrangements noted in sheet No. 2, may be carried into effect. The Fyzabad Dam, or that constructed on the site of the bund C, before alluded to, orginated in the wants of the Delhi Canal and the loss of water that was sustained by using the Nyashur Dam at D, as a Regulator, for the Doab Canal, by which all water not required for the wants of that Canal was thrown into the Jumna, south of the Delhi Canal heads; the inability of the Jumna to supply both the Canals even in the driest months, is a contingency that can rarely occur, but under such contingency the plan adopted of using the Kharra head, and making the Dam at Fyzabad the Regulator, secures the object most effectually.

The Fyzabad Dam was built by Mr. Sub-Conductor Pigott, in 1841-42 and 1842-43, at an expense of 13,880 Rupees; it consists of a platform 44 feet wide, of boulder and stone lime masonry 3 feet thick, with a curtain wall 6 feet deep to the front and rear; on the flanks of this platform over-falls are constructed with revetment walls to connect the work with the embankments, between the flank over-falls, piers of 6 feet in height divide the space into 20 openings, or sluices of 10 feet wide each. It was my intention to have used the lower or Fyzabad Head for the maintenance of the Canal supply during the cold weather of 1843, to have enabled me to lay the Badshah-mahul branch dry, and by so doing have effected a clearance of old box work (the remains of the original bund,) which is now awkwardly protruding itself on the front of the sluice openings of the Fyzabad Dam, as well as to deepen the cut S S S, so as to admit of the Canal water running freely and decrease the head water upon the Dam; this clearance ought to be carried into effect as early as possible; the head water on the sluice gates ought not to exceed 3 feet, which would reduce the size of the gates to very manageable dimensions

—the Bridge which is proposed to be constructed over the line S S S, so as to connect the Choki and Village of Fyzabad with the Dam, would also be built under the advantages of the bed being laid dry. Circumstances prevented this from taking place during both 1843 and 1844—but the sooner it can be done without interfering with other works the better. There is a small Choki at Fyzabad, the remains of an ancient mosque, repaired by me and fitted with doors, but at the Kharra Head there is no cover whatever for either establishment or stores, there is a good spot on an elevated place and overlooking the works which was formerly cleared, and up to which a road was made by me with the intention of establishing a Choki post there—30,000 of the Badshah-mahul bricks were collected at the spot, but other occupations prevented the Choki from being built—as Nyashur, the nearest 1st class Choki is 6½ miles from the Kharra Head, and as it is desirable to have a depôt of tools and stores at the Head works, I strongly recommend that a 1st class Choki (with a masonry roof, so that all chance of fire may be avoided) be established at Kharra. A small Choki, built of brick and mud, which was formerly constructed at A, or the Fyzabad Head, is now in ruins, its fate having been sealed by the floods of 1844, which swept over the island upon which it is situated.

Murti Rajbuha.

17. In the year 1836, in consequence of the great demand for water for irrigation, the bunds of the Delhi and Doab Canals were thrown completely across the bed of the Jumna, and the whole of the water was taken from the river—the bed of the Jumna for some miles south of the lowest bund of the Delhi Canal was laid entirely dry, with the exception of a few pools of apparently still water, and the population of the different villages living on the island formed by the Jumna and Boodhi Jum-

na, who trusted entirely to the former river for drinking water for themselves and cattle, was put to great inconvenience—it was therefore proposed that a water course should be taken off from the Canal at some point south of A, and carried centrically through the island—a profile of the country was taken so as to satisfy myself of the practicability of obtaining our object at a reasonable cost, and an estimate amounting to 16,000 Rupees was submitted to and passed by Government—want of assistance in European or intelligent Native subordinates has prevented this work from being commenced, but it will ere long be taken in hand and completed—the fall of country upon which the water course runs will admit of the introduction of the native corn mill and other machinery if necessary at different points on the high land; and I have no doubt that, although the contingency which led to its being projected may only occur occasionally, the value of the water both for irrigation and drinking purposes will be duly appreciated.

Nyashur Water course.

18. On the high land between the Khadir of the Tanda Nulla, or Reet Row and the village of Nyashur, traces existed of an old water course said to have been dug previously by the Zumeendars of Raipoor; either the bed of the Boodhi Jumna, from which its supply was said to have been taken, had become much depressed since this water course was used, or the work had been a failure, most probably the latter, as there were no signs of extensive or deep excavation having been made, whereas the result of my levels showed that, on leaving the Khadir and entering the high land, the excavation must necessarily be from 20 to 27 feet deep, allowing a moderate slope for the bed of the water course: this great depth of excavation however was not required beyond 4 or 5,000 feet in length, after which the surface of the country

declined rapidly, and at the distance of two miles from its source of supply, a natural flow of water on the surface was obtained for the purposes of irrigation. The Zumeendars of Raipoor and other villages, whose lands would be benefitted by irrigation, appear to have been too poor to undertake the opening of this water course at their own expense, and the benefits likely to be derived by Government by the clearance of forest and increase to cultivation led to a recommendation from Mr. Grant, then Collector of the Suharunpoor District, that Government should be at the expense of the undertaking; this having been approved of, the work was completed at an expense of 4,030-11-3 during the year 1841. The water course left the Boodhi Jumna at the junction of the Tanda Nulla with that river, on a bearing nearly due south towards the village of Nyashur, on the approach to which it broke off into two branches; one running direct upon the Canal Choki, beyond which it crossed the Canal by an aqueduct carried through the flooring of the Regulating Bridge, and terminated in the Canal plantations; another to the south-east to the Raipoor Nulla, which was reached on the southern boundary of the Estate of Mirzapoor; besides the aqueduct on the Regulating Bridge, two small masonry Bridges of communication were constructed on this water course. Between the head and the village of Nyashur, the country was covered with thick forest—the liability to the formation of ravines by the cutting of drainage water into the deep digging was not overlooked, and considerable counter-drainage was designed and executed, so as to relieve the water course from this inconvenience. Immediately after the work was opened, the occurrence of want of rain led to great activity amongst the Zumeendars and cultivators in taking advantage of the benefits offered by the water; from the point where the south-east branch terminated in the Raipoor Nulla, the Zumeendars carried the line forward in prolongation, to the neighbourhood of Jatonwala; the Canal

plantations were irrigated, and there appeared every probability of success attending the undertaking—this however did not prove eventually to be the case, the demand for irrigation in the tracts near and in the forests, is not so great as elsewhere, the returns from irrigation did not pay a moiety even of the expenses of repairs, the drainage of the forest by occasionally making inroads into the deep digging led to very heavy expense in re-excavating the channel, and the inability of the European Overseer to give up his time to this work, with the overwhelming duties of his Division (extending from the head to Ghoonna, and embracing the charge of all the Dams) before him; induced me to discontinue the repairs until a more favorable period should arrive, or until a relief from the heavy duties which *did* at that time occupy the time of the European Overseer, should admit of his looking after its interests. This work is so far a failure: but I am satisfied that the extent of country which comes under its influence, will render its maintenance in a state of efficiency hereafter advisable.

Nyashur or Boodhi Jumna Dam.

19. The Nyashur Dam on the Boodhi Jumna, which is situated at the point where the Canal strikes off upon the high land, and which is intended to maintain the Canal supply, is a work similar to that described at the Fyzabad Dam—it has thirty openings or sluices, 7 feet wide, the ten centre ones (having their sills raised 2 feet above the bed of the river,) being provided with gates—and the ten flank ones being overfalls with their sills or wasteboards, elevated 4 feet above the bed of the river, the upper two feet having vanes or sleeper planks adapted to them. This work is also terminated as at the Fyzabad Dam, with overfalls rising one above the other to the height of 9½ feet, with revetment to connect them with the banks of the river. The

Regulating Bridge, which is situated in the Canal at some distance from the Dam, consists of three arches of 20 feet span each, it is fitted with gates, sleepers, windlasses, &c. When the Dam is thrown open to receive floods which come down the Boodhi Jumna, the gates of this bridge are closed, and the flood water is confined to its escape over the Dam, and down the course of the river. Attached to these works is a 1st class or Office Choki, consisting of a circular room of 20 feet diameter, with a veranda 10 feet wide; this veranda is divided into four porches leading from the outside into the centre room, and four small rooms three of which open out externally, offering accommodation to the establishment, tools, stores, &c. There are also extensive plantations for forest trees attached to this Choki post.

20. The three works alluded to in the last para. were built previously to 1830. The Dam, with exception to the foundations and tail platform in which river boulders have been used, is built almost entirely of ancient bricks brought from Badshah-mahul, the front and rear curtain foundations 5 to 6 feet deep. The mortar used was stone lime and soorkhi. This work, up to the rains of 1841, not only did its work most effectually, but the repairs required annually for its preservation were exceedingly small. The floods of 1841, however, in rising considerably above the flank revetments, turned the Dam on its left flank, cleared away a passage of 200 feet in width, between the Dam and the Regulating Bridge, and carried away the superstructure of the Dam revetment and a portion of that of the left flank overfalls. The flood that occurred when this accident happened lasted for so many days, that it was supposed that a great portion of the main stream had again taken to its old course of the Boodhi Jumna, a supposition that was not realized, but the effect of the constantly running current over the brick work of the Dam was great, exhibited in deep seams worn through the brick work, and in the removal of some of the piers, which were found lying in mass at the Dam tail

21. The extreme height of this very severe flood appears, from the water gauge on the Regulator, to have been 11 feet. At the time when it occurred the Regulating Bridge was entirely closed!—the pressure of water, however, on the gates led to one of them being snapped asunder, and to the admission in the Canal (already sufficiently loaded in its course below the Raipoor Nulla) of a most unseasonable supply of water.

Nyashur Regulating Bridge.

22. The Regulating Bridge is chiefly built of material brought from Badshah-mahul, its foundations rest upon large shingle, it has curtain walls to the front and rear, laid to a depth of 6 feet, its water-ways are counter-arched with brick masonary, (segments of circles with versed sines of 12 inches)—I consider this Bridge to be in every way sound and very solidly built; it requires, however, to be fitted with stone slips and caps for the grooves in which the gates and sleepers work—this stone was prepared by me and lodged in the Choki, and is ready whenever circumstances render its application desirable. A heavy rapid is working back upon the flooring of this Regulating Bridge, the danger is not so apparent when the Canal is running with its full supply; but when this is not the case, it will be observed that a deep narrow gutter or cunette has formed itself in the Canal bed, and this is gradually although certainly making a retrograde movement upon the Bridge foundation; I have been very careful always in watching its progress, and when I last saw it, it was about 100 feet from the Bridge, but the quantity of large boulders which have from time to time been thrown down at the tail of the Bridge, offers a full protection to the work, more particularly as the proximity of the Dam places the water perfectly under our control. An additional tail may hereafter be required, unless boat navigation be considered desirable up to the Jumna, in which case this would be one of

the points where falls and locks would naturally be constructed. This Bridge is situated at a point 415 feet from the Dam.

Nyashur First Class Choki.

23. The Choki is built partly of half-burnt brick and partly of mud, it is plastered on the outside throughout with sand and stone lime, the centre room is thatched and the veranda flat roofed with pukka terrace; the site of this building is exceedingly pretty, it is highly situated (on the river side) with a gradual slope to the water's edge, the water as clear as crystal in the months between the termination of the rains, and the melting of the snow in the Hills—the forest trees, which originally covered this ground on which the Choki stands, have been removed, and the toon, teak, casuarina and sirrus have taken their places; there is at present a fine specimen of the Indian Rubber Tree (Firus Elastica) near the building. I look upon Nyashur as a healthy Choki post. I resided there during the rains of 1841, and neither I nor any of my servants had a day's illness.

Nyashur Plantations.

24. The plantations at Nyashur were established by Col. Robt. Smith; they occupy a strip of land between the Canal and the high road from the Choki to Raipoor, as far south as the Nyashur masonry inlet, on the left bank of the Canal: on the right bank the limits are much extended, being bounded by the Canal and Boodhi Jumna on two sides, and by a boundary ditch on the third, the shape of the plantation being triangular.* This latter piece of ground has only been partially planted. When originally taken for the purposes of plantation, it consisted of a thick forest of high

* The extent of these plantations is 185 begas.

grass, Dak (Butea frondosa) and Kyr (Acacia Catechu.) At some parts this tract was inaccessible from the thickness of the jungle, and offered a harbor to wild animals of various sorts, amongst them the tiger, many of which have been killed within the limits of the plantation. The burning of the grass in these forests which annually takes place, has been a great drawback to the steady growth of trees; attempts were made to check this evil, by clearing roads of 50 feet wide through different parts, so as to divide the whole space into detached portions, the expense of this however led to its discontinuation; but we have gradually succeeded in getting rid of the grass by ploughing up and sowing wheat for a season or two before ground is occupied by trees, making the return for the sale of grain cover the expenses of the clearance. I dont think that above one quarter of this part of the Nyashur plantation has been cleared and planted; but that on the left bank of the Canal, has long been filled with trees,—here are some very good specimens of the Saul (Shorea robusta) brought from the northern slope of the Siwaliks, they were planted by me about 15 years ago, and although they have at three different times been nearly destroyed by fire, they are now thriving well. The toon, sissoo, and sirrus, are the trees which have been most commonly planted, and lately a very ornamental variety of the Acacia (A. superba) has been introduced from the Eastern Deyra Doon, —this tree, which is so remarkably conspicuous in its own native forests from the whiteness of its bark, elegance of proportions, and loftiness of bearing, thrives well in the plantations—the natives call it 'Khurra.' No satisfactory experiments have been made as to the value of its timber—this would be worth while carrying into effect at an early period, as its size, length and straightness would render it an useful accessory to our timber yards. I believe that the Acacias are almost universally considered to be useful either in building or in the arts—a packet of the seed of the Khurra was formerly sent by me to the Secretary of

the Agra Road Fund, but I have never heard whether the seeds vegetated or not. The tree in question may be recommended to all Road Fund Committees, or to those laying out ornamental plantations.

Roads connecting the Nyashur Choki Post, with the Canal Heads.

25. From the Nyashur Choki to the Kharra, or upper Head, a road has been made out of the Canal funds, from this road there are branches to the old or Fyzabad head, and also to the Choki and Dam at Fyzabad. The Tanda Nulla and the Gayjra Row are the chief impediments—the former having a deep and well defined section might be bridged, but the latter, consisting of a wide and shingle bed, merely requires an annual clearance. On the branch road towards the old Head, the Badshah-mahul line of Canal is crossed, a Bridge at this point would be very convenient, three openings of 20 feet wide each would be sufficient, the piers might be massively built of boulders of which the bed of the Canal is composed, and stone lime cement; timbers being thrown over to form the roadway—the cost would be comparatively cheap, owing to the material being near at hand. A Bridge has been already authorized for this branch as before described at S S S, for the purposes of connecting the Fyzabad Choki immediately with the Dam—this Bridge, by being placed in a more southerly point, might by an alteration of the present line of road, answer both purposes, an arrangement perhaps to be preferred, as the multiplication of masonry works in these branches of the Jumna, which are constantly liable to be overcharged with water, ought undoubtedly to be avoided; under the latter plan, the following diagram would exhibit the chain of connection between the main line of road from Nyashur to the Khurra Head, and the Fyzabad Dam and Head.

If the Bridge however is removed from the immediate proximity

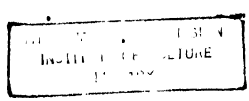
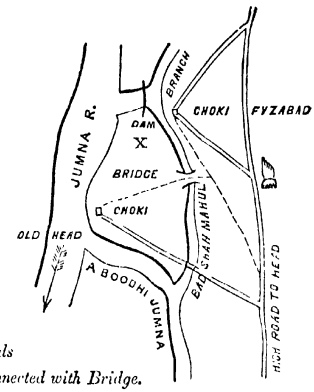


DIAGRAM 1.



Present line of Roads
Proposed Roads connected with Bridge.

of the Fyzabad Dam, it will be necessary to give cover to the bildar establishment, who, during floods, ought to be as near the Dam as possible, so as to be ready to regulate the sluices.

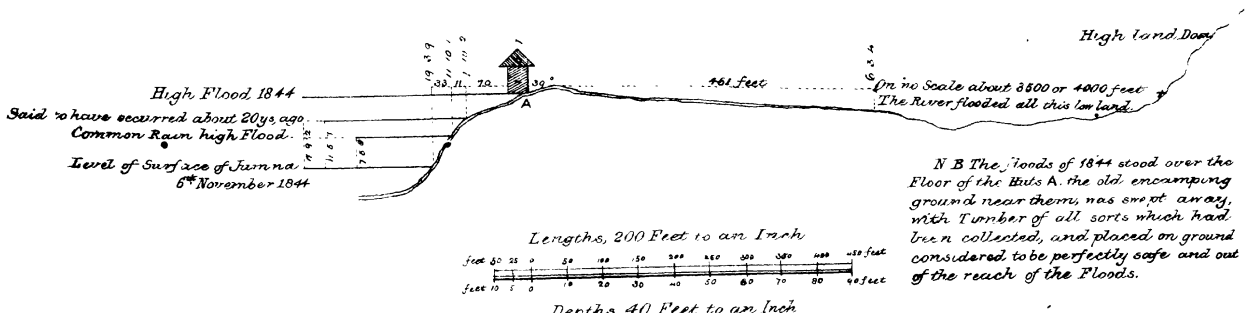
Remarks on the Floods of 1844—*Effects at Rajghat Mundi, Deyra Doon, Fyzabad Dam, and Canal Heads.*

26. The only further remark that I have to make on this section of the present paper is on the extraordinarily high floods of 1844. I have known these rivers intimately since 1827, and can, vouch for nothing having occurred since then, to be compared to them. The following section taken by myself at Rajghat Mundi a large timber mart on the Jumna, in the Western Deyra Doon, will shew the height of flood during the rains of 1814, compared with previous ones. As a proof of the very unusual occurrence of floods of this description, the high land at the Ghat above the levels, shown as that of a flood of 20 years ago, was covered with stacks of timber of various descriptions, which had been collected ready for rafting down the river, and stacked on land supposed to be out of the reach of the highest floods—the greater part, in fact

LEVELS on the JUMNA at RAJCHAT MUNDI

DEYRAH DOON

Shewing the height of the Floods in the rains of 1844 in comparison with those of other years.



N B The floods of 1844 stood over the Floor of the Huts A. the old encamping ground near them, was swept away, with Timber of all sorts which had been collected, and placed on ground considered to be perfectly safe and out of the reach of the Floods.

nearly the whole of this timber was swept away, and property to the amount of 3000 Rupees is said to have been lost; this is a large sum, considering that the timber at the Rajghat sells at a very moderate price. The effect, however, on the Canal works was serious, although the buildings of masonry suffered little injury. The mouth of the Kharra was blocked up by a high bank of shingle and large boulders, and the Canal channel was completely obliterated. The Fyzabad Masonry Dam appears to have had a body of water flowing over its pier heads equal in depth to 6 or 8 feet. The island marked X in Diagram I—which, at the point where the Choki is built, is more then ten feet above the surface of the Jumna, in the cold weather was covered with water, and old channels which intersect this island, which had become choked up and covered with trees arrived at the age of maturity, were cleared out, and the trees thrown prostrate in the direction of the current—the old or Fyzabad Head was not much injured, but a flood of 11 feet in height came down upon the Boodhi Jumna Dam, at Nyashur, doing the injury before explained (in para. 20)—the effects of the flood on the Fyzabad Dam will be best shown by a diagram, the water paid no more respect to this work than if it had not existed; after far over-topping the piers and holding the Dam "in the deep bosom of the ocean buried" for a considerable period, the water subsided, leaving the work a literal skeleton, both flanks had been turned, and the work in both revetments piers and overfalls, was standing in relief, *without one brick of the structure having been displaced*, the following will explain the state of the Dam after the flood.

Fyzabad Dam further alluded to.

27. During the floods of 1843, the set of the current down the Badshah-mahul branch was evidently upon the island flank of the Dam: this flank was turned at that period, but to a small extent,

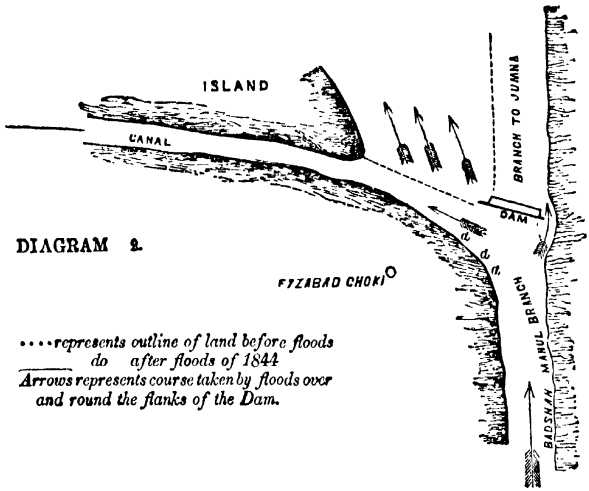


DIAGRAM 2.

....represents outline of land before floods
_____ do after floods of 1844
Arrows represents course taken by floods over and round the flanks of the Dam.

and the embankment connecting the Dam and Island was restored; spurs were also established at the shoulder *a a a*, so as to give the current an inclination upon the Dam sluices; these were of course washed away during the heavier floods of the following year, but it will be necessary to reconstruct them, and every endeavour ought to be made to relieve the flank of the Dam as well as to strengthen the embankments in that flank, so that future fractures may be avoided.

28. The original project placed the Bridge of communication to the Choki on the island flank—to be connected by a line of masonry revetment with that flank; it was fortunate that this part of the plan was never carried into execution, the whole would certainly have been submerged during the floods of 1844, and the Bridge would, in all probability, have been carried away.

29. As both the Fyzabad and Nyashur Dams are built on rivers, the beds of which, although running on a considerable

declivity, consist of boulders of rock, any dangerous retrogression of levels on their platforms or tails is not to be anticipated.

SECTION II.

Nyashur Choki to Kulsea Choki.

30. Between the Nyashur Regulating and the Raipoor Bridge there are no masonry works of any extent, the Nyashur inlet situated on the left bank and on the boundary of the Nyashur plantations has acted efficiently for the drainage of the country in its neighbourhood, and the Raipoor inlet, a somewhat larger work on the same bank, consisting of two openings of 6 feet wide each, appears to be also efficient, although at two different periods the water from the country has risen over the roadway flooring and carried away the banks in its neighbourhood; as the masonry has not been injured on these occasions, and as in all common years the capacity of inlet through these two openings has been sufficient, I have not thought it worth while to make any alterations; this inlet, however, drains an extensive tract of forest land through a ravine, which is crossed on the high road between Raipoor and Nyashur. On the right bank of the Canal one irrigation outlet exists at the head of a rapid, which appears to have retrograded to such an extent as to have led to the desertion of the outlet; formerly however, this was the head of a very fine line of water-course which ran south and parallel to the Canal, crossing the Raipoor outlet of escape by a masonry aqueduct, constructed parallel to the flooring of the roadway—this water-course continued to the land of Allumpoor, and even to the left of the Allumpoor escape, which it crossed by a temporary wooden aqueduct, large tracts of land, which at the time when the Canal was excavated were lying waste and covered with forest, were broken up and

cultivated under the irrigation from this water-course. During late years, however, no water has been taken from the outlet; should this arise from the retrogression of the Canal rapid having left the flooring of the outlet high and dry, I would recommend that another head for irrigation be established further north, so as to be free from the influence of the rapid, the maintenance of this line for irrigation appears to me very desirable.

Raipoor Bridge.

31. The Raipoor Bridge consists of three spans, the centre of 20 and the side ones of 15 feet each in width—the foundations are laid on a boulder stratum, and are built on the plan universally adopted by Col. Smith in all his bridges on this Canal, consisting of front and rear curtains with counter-arches on the same form of curve as described in para. 22: the depth of foundations at the Raipoor Bridge is 3 feet, and they are built of river stone and brick, the width of roadway is 12 feet,—immediately south of the Bridge on the left bank is an inlet for the drainage of the town of Raipoor; this inlet is connected to the Bridge by a line of Ghat built partly for the convenience of the town, and partly to protect the wing wall of the Bridge, and the slopes from injury arising from the wear and tear of a rapid which has established itself upon the tail of the Bridge. The slopes and earth covering the wing wall on the right bank are much out of order, and will not be protected properly until a Ghat similar to that on the opposite side is constructed; an inlet drain on this side also will be an improvement; the rapid on the flooring of the Raipoor Bridge is a severe one, but as the bed of the Canal consists of boulders, I apprehend no danger to the work, if properly watched and looked after—south of the Bridge and cattle Ghat, which is not far off, there is much cutting on the left bank, at the junction of the Raipoor Nulla, at which point the Canal makes a turn to the right, and the stream necessarily

makes a set upon this bank. From thence the Canal takes to the old course of the Raipoor Nulla for about two miles as shewn below.

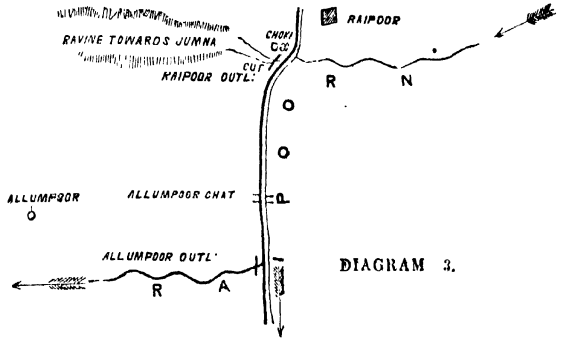


DIAGRAM 3.

A survey of the ground during the time that the operations were in progress showed, that immediately opposite to the town of Raipoor, an extensive tract of low raviny land extended, approaching to within a short distance of the Raipoor Nulla, and terminating in the Boodhi Jumna,—this ravine was taken possession of by Col. Smith by a cut made from the Canal, on which was constructed an outlet of escape which bears the name of the Raipoor outlet, attached to which is a 2nd class Choki, a thatched circular room of 20 feet diameter. The retrogression of levels upon the Raipoor Bridge, and consequent lowering of the level of the Canal bed, made it necessary, shortly after the Canal was opened, to depress the floorings of this work 4 feet* and to clear out the channel to

* Since that period a still further retrogression has taken place, the surface of the Canal water is on a level with the platform, and it is only in floods that this escape is available: the floorings might be lowered with advantage another 4 feet, but in this case the tail must be well protected as an alteration of this sort will leave only 4 feet in depth of foundation remaining.

the same depth. The outlet is situated at a short distance from the Canal stream, and from its being covered in a measure by the shoulder *x*, is liable to be silted up to a certain degree, it is absolutely necessary that this mouth, which is bell shaped and capacious, should be annually cleared out and freed from grass and other impediments to the free escape of the water—the same remark applies to the whole course of the channel of the escape nulla after it has left the masonry work—this consists of three openings 6 feet wide each, the height to the crown of the arch being 10 feet 10 inches—the foundations are massive and built in curtain walls 8 feet deep—the whole is built of the best brick masonry, with cement made of stone lime and soorkhi. The roadway is $12\frac{1}{2}$ feet wide, running parallel to the aqueduct of the Allumpoor water-course which occupies a width of $6\frac{1}{2}$ feet—the water channel is $1\frac{1}{4}$ feet at bottom, $3\frac{1}{4}$ feet at top and 2 feet deep—the uses to which this aqueduct has been applied have been before explained—the water-course at this point is 12 feet 4 inches above the platform of the escape. The course of the Raipoor Nulla occupied by the Canal has been cleared out considerably by the current acting on a rapid slope, and its sides have also suffered. Shingle and boulders occur to a point as far south as the Allumpoor Ghat, (*vide* diagram 3,) after which the bed consists of sand, more or less mixed with clay. The next masonry work is the Allumpoor outlet, situated at the departure of the Raipoor Nulla, this has two openings or sluices of 6 feet wide each, built on solid foundations, with curtains sunk to a depth of 12 feet, the platforms are of masonry, and the tail, which is semi-circular, is covered by a deep foundation wall sunk to the same depth as those of the body of the work, the whole is protected by piling—this work is built of brick masonry. The nulla requires a good deal of clearing out to render it efficient as an escape. This outlet is inconveniently situated and at a distance from the Choki posts at Raipoor and Gundewur, its supervision therefore, has been somewhat neglect-

ed—the masonry outlet is in good order, but the wood-work requires renewal—the channel of outlet, however, has been choked up both with silt and jungle, and requires a radical repair and clearance; this ought to be done as early as possible. No embankments were ever formed on the left bank of the Raipoor Nulla, which at the time of the nulla being cleared out for Canal purposes, ran through a dense forest, the drainage of the country on this side, therefore, enters the Canal through natural hollows and ravines—on the right bank, along which the Canal road has been formed, the drainage has been confined to certain points of inlet over which trunks of trees, &c., have been thrown so as to form a roadway and keep up the line of communication: it would be an improvement were masonry drains built at these places they might be built on the plan of the Nyashur inlet, which consists of an horizontal main channel, connected with a well or cylinder (constructed in rear of the roadway,) into which the water falls, and passes off to the Canal through the main channel; works of this sort would prevent the obstruction to wheeled carriages, which occasionally occurs during the rains, by the breaking down of the present wooden passages.

Gundewur Choki, Bridge, Inlet and Outlet.

32. Between the Raipoor Nulla and the Nogong Rao, the only masonry works that exist are the Gundewur Bridge and the inlet and outlet connected with it. This Bridge is similar in every respect to that at Raipoor; adjoining and connected to the Bridge by a curved revetment on the right bank is an outlet of escape, consisting of two openings of 6 feet wide each, between which is a 2 feet opening for the purpose of irrigation; on the left bank and uniformly situated is an inlet acting as a 'Gao Ghat,' or place for cattle to obtain water for drinking. A 2nd class Choki, of the same description as that at Raipoor, is situated close to these works.

The style of foundation is the same as before, with counter-arches and curtain walls, the latter being sunk to a depth of 9 feet, the whole is built of brick masonry. At present there is a very heavy rapid on this Bridge arising from circumstances which I shall hereafter explain when summing up the history of the Belka and Nogong works; at present the tail of the Bridge is protected by rafters of timber, piling, hurdle and frame box-work filled with boulders, it merely requires careful looking after for the present and should the contingency of the rapid acting dangerously upon the curtain wall of the Bridge occur, the Canal water must be turned round the Bridge through a cut which has been already prepared for that purpose—the whole of these buildings are sound and in good order. Owing to the retrogression of levels in the Canal bed, which has taken place in the line between Gundewur and the Nogong river, the transverse section of the Canal has been greatly disfigured, a portion of the right or roadway bank has been destroyed—and it has been necessary to make a new line of road in the rear of the boundary ditch. 14356

33. Between Gundewur and the Nogong Dam the drainage of the Jatonwala Rao is crossed. At the time that the Canal was excavated there was no mark whatever of any river across the Canal alignement—this Jatonwala Rao was in fact similar to those that I have described in the 6th para. of my 1st report on the Ganges Canal—the defined bed of the river terminated north of the village of Umbita, at a distance of about 5000 feet north of the Canal, after which the flood water swept over the country; for many years after the Canal was opened the floods of this river used during the rains to pass directly across the line of Canal, paying no regard to the embankments, and doing no further injury than that arising from an annual fracture to the roadway or right bank; an opening was left on the opposite bank for the admission of the water, the depth of section in the earth being capable of holding the full Canal supply without any fear of inundation.

Nogong Dam.

34. The Nogong Dam is a work constructed across the bed of one of the rivers which drains a considerable tract of country; its head is chiefly supplied from two of the passes in the Siwalik mountains, situated about 7 miles north of the Canal works—the bed is perfectly dry, excepting during floods in the rainy months, and at the point where the Dam is built the fall per mile is 11 or $11\frac{1}{2}$ feet. When the original Dam was built in 1828-29, water was found at a depth of 29 feet from the bed of the river, kucha or temporary wells gave but a limited supply of water, and that used for the works was chiefly brought from Behut, a town situated about one mile off—the section of the soil, as exhibited by the shafts sunk for wells near the Dam, shewed a succession of strata of sand and clay, the latter being in beds of considerable thickness at some points—a depth of foundations, equal to 12 or 13 feet, however, was considered sufficient, the system of curtain walls to the front and rear was adapted to the body of the building, and to secure the work still further, aprons were built both in front and rear of the sluices, the former 10 and the latter 20 feet in width, with foundations of an equal depth with the body of the building—the form of Dam was as before described for the same sort of building at Nyashur, adapted to 24 sluices of 7 feet wide each, the eight centre ones having gates of 4 feet in depth, and the side ones sleepers—the sills of the centre gates were 2 feet, and that of the side sluices or half overfalls, 4 feet above the bed of the river—the flank overfalls were placed so as to meet a flood of 9 feet in height. On the left flank the body of the Dam was connected to the high bank on the main line by a revetment 250 feet in length, with foundations laid in to the same depth as the rest of the work, the front being protected by a line of piles driven at a distance of 10 feet from the foot of the revetment with the intermediate space filled with heavy material—

the back was covered by an earthen embankment of 20 feet in width. The tail of the body of the Dam was also protected by piling.

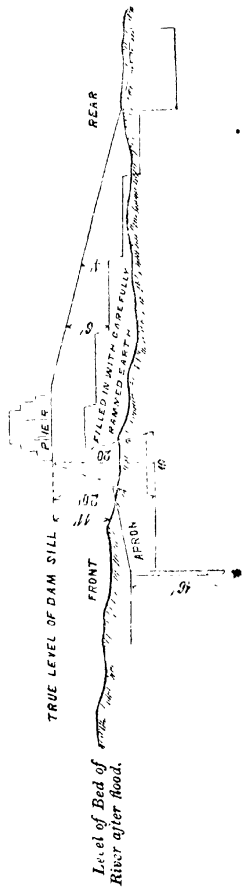
35. From the rains of 1830 to those of 1834 a constant succession of retrogression of level upon the masonry tail of this work took place; in the rains of the latter year, a portion of the tail apron fell, and a new tail was constructed partly of masonry and partly of timber and boulders flanked by hurdles and fascines; this work cost about 2800 Rupees—it was formed on a slope so as to meet the depressed level which the bed of the river had assumed at and south of the tail of the Dam—at the commencement of the rains of 1841 the total width of the box with tail on its transverse section was 80 feet, year after year extensions had been made, and, as it was hoped, addition given to its stabilty; early in the rains of 1841 however, during the time that I was residing at Nyashur, a very heavy flood came down the Nogong river, the water in its passage over this fearful rapid of box-work (the bed of the river south of the tail being at this time 21 feet below the sill of the Dam,) turned the piling and hurdle-work on the left flank, carried away that portion of the tail in its immediate proximity, and was only checked by the masonry platform, over which it fell in a cascade of at least 15 feet in perpendicular height. The foundations of the Dam, it will be recollected, were only 12 or 13 feet deep: in this state of things, therefore, the water on the upper side had a natural tendency to get underneath the body of the Dam, and blow up the work, the injury was of such magnitude that neither time nor material were available for doing anything further than a moderate repair, and the only prospect that appeared of preventing irreparable injury, was by passing off flood water down the Canal, and, if possible, putting the Dam out of use for the rest of the season; fortunately, the floods that came down the river during the rest of the rains were so small, that they were all passed off down the Canal; had this not been the case, and had floods similar to the former occurred, the accident which afterwards happened to this Dam would most assuredly have been

anticipated. It was evident that no wood-work platform, or slope was capable of withstanding so great a rush of water as we had at this period to contend with; in the proposed repair, therefore, in addition to a modification of the sluice openings, by which a more capacious escape was effected, I proposed that a massive masonry talus or slope, with its foot resting in a curtain wall, (10 feet deep, with a width on its transverse section of 20 feet, a mass of masonry which it was supposed would preclude all chance of failure,) and with its flanks protected by revetments, piling, &c., should be constructed, the estimate to the amount of 18,000 Rupees was passed by the Government. The collection of river stone, lime, and more especially the manufacture of bricks for soorkhi, prevented the work from being commenced until the December following; there were great difficulties to contend against in sinking foundations in the immediate proximity of water running 31 feet above the lowest part of the work, but we had 5½ months to carry on our operations in, previously to the floods that might be expected in the middle of June. The charge of the work was entrusted to the assistant superintendent who retained it until it March, when fever and illness temporarily deprived me of the value of his services; the only European at my disposal was Sub-Conductor Pigott, the overseer of the northern division; he was at that time building the Dam at Fyzabad, superintending the bunds on the Muskurra, at the other extremity of his division, besides the usual routine duties, and to these now were to be added the works at the Nogong Dam. I had visited these works a short time before the floods might be expected, and although it was impossible that the cement could be sufficiently indurated, I saw no fear of the work not being ready to receive floods, unless they visited us earlier than usual. At this time Mr. Pigott was very seriously ill, but able to go about in his palankin—it was proposed that to give the works as much time for induration as possible, floods should be passed off down the Canal in the same way as was

managed with such success the previous year, should the season commence moderately. On the 23d of June 1842, however, a most unusually heavy fall of rain, confined as it appeared to the upper part of the Doab, led to the whole of the rivers connected with the Jumna, as well as those in the neighbourhood of Meerut, being flooded to an enormous extent—the coffer dams built for the protection of the sluices at the Nogong works, were either not or only partially removed; the water swept over the works, and to all appearance carried the whole of the centre portion away, leaving the side revetments alone standing. This removal of an obstruction to the course of the current, led to an entire change in the bed of the river—the abrupt step formed at the tail of the Dam was obliterated, and the bed of the river had assumed one uniform slope, the deposit over the tail of the Dam being 10 or 12 feet in depth. The amount expended up to the period of this accident was 16,486-11-9, besides the material collected on the works. The loss however was not so great as was expected; in clearing away the sand about one-third of the lower part of the masonry talus was found uninjured, with the whole of the curtain foundations, and a portion of the revetments. The state of the existing levels of the bed of the river, offered great facilities for the construction of the foundations of a new Dam; the surface of the bed was from 10 to 15 feet below the true level of the sill of the Dam, and what was of still greater consequence, a stratum of clay was laid bare on the whole line upon which the foundations had to be built—the following *(see opposite page)* is the section which was adopted for the new masonry work.

The Dam was proposed to be fitted with 12 sluices of 10 feet wide, each with stone piers $1\frac{1}{4}$ feet in width, so as to offer as little obstruction to the passage of water as possible, the front foundations were to be protected in the manner above shewn, by a line of 16 feet piles, with a solid apron connecting them with the body of the building—the talus was to be repaired and flank revetments

DIAGRAM 4.


REAR
FILLED IN WITH EARTH RAMMED HARD
PILE
TRUE LEVEL OF DAM SILL
FRONT
APRON
Level of Bed of River after flood.

raised so as to admit of the passage of a flood 9 feet in depth—the body of the building was to consist of boulders laid in a cement of stone lime and soorkhi, faced externally with brick—the talus was also to have a pavement of the latter material. Lieutenant A. D. Turnbull, of the Engineers, at that time engaged on the Ganges Canal works, was called in to superintend its construction; much of the old revetment which had been shaken had to be removed, and, as is usually the case in the repair of an old work, the contingencies of extra expense were unavoidable—this work was completed before the rains of 1843, at an expense of 32,720 Rupees. The floods of 1842 having, as before noticed, deposited a deep stratum of silt over the lower part of the Dam tail, as well as along the whole course of the river south, I projected a work at some distance from the tail under the name of, a retaining Dam, for the purpose of retaining the levels of the bed as they then were, and protecting the masonry Dam from retrogression of levels—the work in question consisted of two parallel lines of 16 feet piles driven 40 feet apart across the bed of the river, the intermediate space being occupied by frame boxes sunk into the bed to the depth of 4 or 5 feet and filled with stone; the whole was tied together by sleepers fastened by spike nails, and the platform was protected on each flank by a revetment built of the same material; the total cost of this work was 3,964 Rupees. The object of the retaining Dam was merely to prevent the levels of the bed from retrograding upon the masonry work, and thereby keep the evils arising therefrom at a distance. Both in the rains of 1813, and those of 1814, the retaining Dam has done its duty most efficiently, and, as far as I can at present judge, is likely to prove a most successful expedient. It is more than possible that had this plan of removing the retrogression of levels to a distance from the main work been acted upon in the first instance, the original masonry works might have been in existence to this day! It is a fact which I can't conceal from myself, although the effect that the construction of these

masonry Dams was to have on the beds of rivers running on steep slopes, was neither anticipated by me, nor apparently by others.

36. About 2 miles below the site of the Nogong Dam, a very serious rapid is at this time gradually working back in the bed of the river, it has for some years been fixed upon a stratum of a very compact clay, which resists its action to a degree, but it will not be many years before the establishment of other retaining Dams will be necessary—in the year 1836 the descent was about 6 feet in two furlongs—the stratum of clay being worn into seams by the attrition of the current, which had formed deep bays or pools of water at its tail—the rapid has retrograded considerably since that period, but is still on clay; Lieut. Baird Smith, the Executive Engineer in charge of the works, notes annually the position of this rapid and its rate of retrogression.

37. The steps of descent from the flanks of the Nogong Dam to the pier heads and flooring have slightly separated from the body of the building—the separation is a deformity in appearance only, and arises from the step foundations not having been laid in to the depth of those of the rest of the work—settlement of this sort I have generally found to continue for a number of years, but it ultimately ceases.

38. The revetment on the Choki side of the Dam, is that originally constructed: it is protected in front by a line of piling and river stone, the foundations however are neither so massive nor so deep as those of the new Dam, and as the Nogong river is inclined to make a set upon this revetment, it must be very carefully watched, and the line of piling and protecting offered by the boulders rigidly maintained:—this is the only part of this work which is open to danger, and it may be perhaps hypercriticism to say even, that this is the case—stone piers were planned on the idea of relieving the waterway from obstruction by admitting of a more contracted dimension to the pier—those as the Nogong Dam consist of three large masses sunk perpendicularly with a stone cap acting

as the upper part of the pier; iron rods let in to the upper and lower stones holding the upper slab in position thus :—

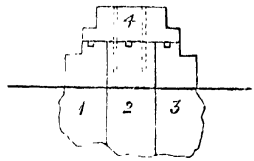


DIAGRAM 5.

Nogong Choki and Irrigation Outlet.

39. The Choki at this Dam is 2nd class, of the same dimensions as those before described—on the right bank and close by the Choki is a masonry outlet for irrigation, which is well adapted as a head for all the country near the town and in the neighborhood of Behut.

Belka Falls.

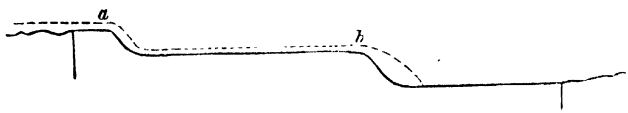
40. At a distance of 2000 feet from the Nogong Dam, and between that work and the head of the Behut Khala, the Belka Falls are situated; at the head of these Falls is a Bridge adapted to the purposes of a Regulator, for confining the floods from the Jatonwala and Nogong rivers to the Nogong Dam Escape—the work was constructed in 1830-31 on the site of the old bridge referred to in para. 13; at that time it consisted of two chambers, one of 15 and the other of 20 feet wide; each chamber divided into two descents of $7\frac{1}{2}$ feet each; that of 15 feet in width was projected for lockage, the form of descent, in ogee curves—the total cost of the work was 11,693 Rupees. It was intended here, as in other cases where the original Falls were constructed, to add another chamber of 15 feet when the increased demands for irrigation should require it.

41. The foundations of the whole of the work were laid in in curtain walls without any interference from spring water, those

under the bridge to a depth of 13 feet, with clay and boulders in front; and those at the tail of 8 feet deep, the latter being protected in front, by a platform of stone confined by piling and sleepers.

42. There was an error in the design for these descents which was completely overlooked by me: it arose from my not taking into calculation the initial velocity at the head of the lower descents after the water had fallen 7½ feet. I can best explain the result of this error in construction by a diagram.

DIAGRAM 6.



The dotted line representing the form of the surface of the water. The water at *a* passed smoothly over the ogee, but on its arrival with a velocity due to a fall of 7½ feet at the point *b*, it fell in a cascade independent entirely of the ogee curve. When the water was first admitted over the Falls there was a good deal of back water in the lower chambers, which relieved the floorings in a great measure from the action of such a body of water falling upon them. South of the Falls however, and between them and the Muskurra works, there was still a descent of 12 or 13 feet, on a line of about 3 miles in length, somewhat tortuous certainly, but over a sandy bed. In August 1837, after we had done all in our power to oppose the retrogression of levels upon the tail of these Falls—and at a time when it was considered that this had been done effectually, at least sufficiently so, until another set of Falls could be built south, the lower chambers sank, owing, in all probability, to the subsoil having been carried away by percolation, arising from the head water acting under the foundation upon soil not sufficiently protected by the tail foundation wall, which wall had been laid bare

by the retrogression of levels. Opportunity was taken of this accident to build an additional 15 feet chamber parallel to the two which were formerly built, and in re-constructing the lower or second descent, to adopt the form of an inclined plane instead of the ogee, the slope of the inclined plane being 1 in 6 feet, the tail work, which at this period had a length of 100 feet in transverse section, was also greatly improved and strengthened. This work, from first to last, was built by Mr. Sub-Conductor Pigott. The alterations and repairs above described cost 16,781 Rupees.

43. It was found convenient shortly after the Falls were constructed in 1830-31, to build a Mill for grinding corn for the inhabitants of Behut and its neighbourhood, and the best and most economical position for the said Mill was in the rear and attached to the revetment of the upper descent,—there was a choice of evils in this arrangement, as, were the Mill built on the lock chamber, lockage would prevent the Mill from working; were it built on the larger or 20 feet chamber, the construction of a third chamber of 15 feet in correspondence with that on the opposite side, would necessitate the removal and pulling down of the Mill. The prospect of the Doab Canal being locked was remote, that of the construction of the additional chamber was more immediately certain,—at any rate, the Mill if built on the lock chamber, could work until the time for lockage arrived; and when this did take place the building could be turned into a Choki or store-room, and a Mill corresponding in form and elevation might be constructed on the revetment of the opposite 15 feet chamber. The plan which has been adopted has not only saved the building, but led to an uninterupted income from mill rent up to this period. As the time however for lockage has now arrived, I should recommend that no time be lost in adopting the plan before referred to, of constructing another building for the purposes of a Mill on the opposite flank, and converting the old Mill into a Choki, or store room, by completing the sluice arrangement for filling the Lock chamber, taking posession of

the inlet and outlet of the Mill for that purpose, and by making a floor to the room on the same level as the plinth of the building.

44. At the Belka Falls, the tail platfrom and piling ought to be carefully inspected whenever the Canal is laid dry,—the masonry I believe to be unexceptionable, it consists of brick and stone lime and soorkhi cement, the floorings of the lower chamber are strengthened with river boulders: the floods of 1844 did no injury to this work.

45. The transverse section of the Canal bed south of the Belka Falls, which in 1829 consisted of an excavated channel about 4 feet deep, of the usual trapezoidal form, was, at the period when the Falls were completed a ravine about 25 feet deep and 100 in width,—the cutting that had led to this ravine brought to light some singular antiquities, amongst these was the site of an old town, shewn by a stratum of black soil and clay filled with pieces of broken pottery and bones, the section was apparent for a distance of some thousands of feet along the line of the Canal, with a superstratum of soil of 17 feet in depth above it, bricks and the remains of old walls were here and there exhibited; numerous coins, entirely Hindoo, of a new type of the Indo-Scythic period, were collected,—arrow heads, rings, rolls of metal, iron slag, &c. &c. were discovered, an account of this Indian Herculaneum will be found in the Journal of the Asiatic Society with remarks upon and drawings of the coins by my most lamented and talented friend James Prinsep. A masonry well was also laid bare at a point south of these old ruins, and on clearing it out, the horns and bones of deer were exhumated.

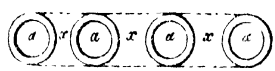
Behut Falls.

46. Subsequently to 1837, the fall which existed between the tail of the Belka Falls and the Muskurra Dam has been disposed of, by the construction of an intermediate set of Falls on the high land between the town of Behut and Ullooni, this work has been denominated "the Behut Falls," it consists of three chambers simi-

lar in width to those at Belka, with a fall of 8 feet over an ogee curve, the right chamber planned for lockage—at the head of these Falls is a bridge of three 20 feet spans, the side ones providing a towing path of 5 feet in width. This work was built by Mr. Pigott and completed in March 1841, at an expense far exceeding the estimate, arising in a great measure from the difficulties experienced in laying in the foundation, from the nature of the soil which was filled with springs up to the surface.

47. The foundations of this work consist of wells or cylinders 6 feet in diameter, those of the chamber revetments being sunk to a depth of 10 feet below the surface, those of the bridge to a greater depth, generally speaking, 13 or 13½ feet—those wells which are underneath the central portion of the work are placed 4 feet apart and connected by piles and rubble work arched over; the front foundation or the line under the sill or wasteboard of the bridge consists of 6 feet wells placed *close together;* the tail foundations have a similar arrangement, the cylinders at this point however are 8 feet in diameter—the wells when sunk to their full depth, are filled with masses of stone or kunkur *without* cement, it being intended that in the event of an eddy causing excavation at the curb or nemchuk, the heavy material in the cylinder might by subsiding or sinking down, fill up the space so excavated and give additional strength to the superstructure—the tail is protected by piling and box work covered with sleepers. The following is the plan of laying in the foundations with wells, in soil with spring water on the surface

DIAGRAM 7.



a a a a wells sunk 10 feet deep.

. . lines of 5½ feet piles—a length adopted from the common

small rafter which is procurable in abundance, being 11 feet in length, these are sawn in two pieces.

After the piles are driven close together to a depth of $5\frac{1}{2}$ feet, the soil at x is taken out as deeply as possible without disarranging the piles, this space is then filled with beton, or concrete well beaten down. The wells are then covered in by a dome of brick masonry, and an arch is thrown from one well to the other: the wells I have before explained having been previously filled with river stone, kunkur, or masses of overburned brick from the kilns.

48. The Behut Falls are well and massively built, and I believe that the work is sound in every respect—during the rains of 1844, a flood rose up to the cordon of the upper front, about 2 feet above the crown of the arch, without any accident arising therefrom. I shall recur to this hereafter; the tail platform of this as well as that of all works of this description must be examined, and if necessary repaired whenever opportunity offers. This work cost 22,886 Rupees—a 2nd class Choki is required at this work for the lockage establishment.

49. The Canal after passing the Behut Falls runs for a distance of about 4000 feet down the course of the Behut Khala, it then enters the bed of the Muskurra river, down which it runs for another 4000 feet or thereabouts, until it reaches the masonry Dam near Kulsea.

Muskurra River.

50. It becomes necessary at this point of my narrative, and before a description of the Dam is entered into—to describe the Muskurra river itself; for this purpose I must refer to the accompanying plan.

51. The Muskurra river rises directly in the Kalowala pass of the Sewalik Hills, at a distance of 13 miles north-east from the Dam at Kulsea; in its course it is fed by three other rivers also

rising in the Sewalik Hills, viz. the Kulkur, Jytpoor, and Sunsurra raos, each of them carrying a large body of water during the rains. I have before stated that at other periods of the year the beds of the mountain torrents connected with the Doab Canal Works (amongst which these are the most formidable) are dry, sandy, and of great declivity.

52. Had nature in laying down the alignement of the Muskurra river in its present course, intended it as a bar to the construction of the Doab Canal; had she persisted in maintaining that course and that course only, and left the Engineer to dictate the position and direction of the drainage on its left or southern bank, the Engineer would, to suit his own views, have placed the heads of the Hindun in the situation which nature has actually assigned to them. The Dumola, Nugadeo, and Chycha nullas, which ultimately fall into the Hindun, it will be observed, have their heads within a short distance of the line of the Muskurra river, the Nugadeo especially, whose head commencing in a wide bed, approaches so marvellously near to it that looking at the bearing of its course as connected with that of the Muskurra, it is difficult to avoid the belief that the course of the Nugadeo has at some time or other been that of the Muskurra.

53. Lieut. Debude in his project for opening the Doab Canal saw at once the advantage to be attained by taking possession of these heads of the Hindun, and by connecting them with the Muskurra (immediately south of the feeders before alluded to), either get rid of the Muskurra as an impediment to the course of this Canal, or reduce its volume to such an extent as to render it innocuous.

54. *Plans* of rivers however require *sections* to make them intelligible! Whenever any peculiar lining out of a river is observable on a map it may be certain (supposing that map is to be depended upon,) that there is something in the levels of the country or in the topographical features which the map does not or cannot exhibit, which has led to the peculiarity. The natural course of

the Muskurra appears to be in a direction where the greatest fall exists, and therefore although we may by artificial means and by dividing the volume of water dispose of it by cuts made into the Hindun—its natural tendency is and always (in the present state of the earth's surface) will be, to keep to its present channel.

55. Nos. 1, 2 and 3, or the Kalowala, Dowlakooa and Ullooni cuts were made previously to my joining the works—the width of excavation was 30 or 40 feet. My initiation in the department commenced on these works, having been detached in the month of May 1825, to superintend the clearing out of their mouths and channels, and in establishing spurs so as to give the floods an inclination towards them—at this time the cuts, although exhibiting evident signs of being natural excavations were much increased in size; Col. Smith's object appears to have been (after having dug the original cuts) to have merely given an annual clearance, with an annual extension of the spur or bund, so as to let the river itself clear out its own passage by degrees—this arrangement was attended with the greatest success, and in the year 1830, the cuts having been again cleared out, the bunds were established directly across the bed of the river at Nos. 2 and 3, and about half across that at the Kalowala, No. 1.

56. The Kalowala and Dowlakooa works, which are constructed at points where the bed of the river consists of boulders, had always done their duty efficiently, the cuts had been getting gradually deeper as well as wider, and the set of the stream, especially at the latter point, was decidedly towards the mouth of the Nugadeo—the position of the Kalowala cut, although the only one that could have been properly adopted, was awkward; a spur of the mountains gave the current a natural direction towards the true line of the Muskurra, and the slope of the bed was so excessive that all common varieties of bund failed—the results were, however, satisfactory.

Ullooni Cut and Bund, No. 3.

57. At the Ullooni Cut matters were altogether different—the river here consisted of a wide shallow bed of pure sand, and the cut which was excavated through the same species of soil was on a small slope, the annual clearance was expensive, and the bund or spur which was made of sand, covered with thatch and protected by hurdles and fascines was annually swept away, without a vestige of it remaining. I have before remarked that in 1830 the bund at this point, which had previously been only carried partly, was carried right across the bed of the river, the consequences were nearly fatal to the masonry Dam at Kulsea ; after sustaining a heavy flood until the water rose 10 feet, at which time the bund gave way, the collected water passed on in a wave to the Kulsea Dam ; the flood which during the time that the bund lasted passed down the cut into the Dumola river, did much damage—the village of Ghanna, situated on a loop of its course was nearly swept away, and it was evident that supposing that the Ullooni Cut could be maintained, the capacity of channel of the Dumola was unable to retain the water that it would be liable to in floods—this discovery, with the general inefficiency and expense of No. 3, or the Ullooni Cut, led to its abandonment in 1831.

Kalowala Bund and Cut, No. 1.

58. The Kalowala work has been maintained up to the present time with the greatest care, and in defiance of the position of the cut, there is every tendency to the object being perfectly obtained ; in 1836-37 the bund at this place was much strengthened, and re-constructed in that part where strength was particularly required, of frame boxes loaded with stone : the course of the river at the foot of the hill was deepened, and other improvements necessary to the change of the course of the river undertaken—at this time, the cut which was originally dug 30 or 40 feet wide, is

a huge river of at least 500 feet in width—a large mango grove and Hindoo building which existed on my first visit in 1825 are gone, and their former site is now the middle of the bed of the cut: the following diagram will explain matters:

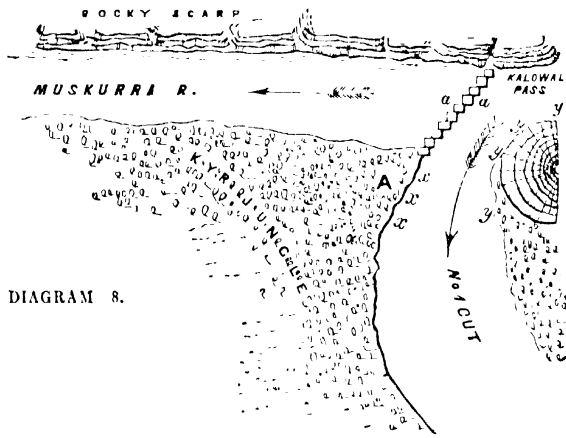


DIAGRAM 8.

The bund is built of boxes placed in echellon in double line at *a a* which is the deepest part of the river, and open to the full action of the torrent; it has suffered considerably since 1837, but it has so far done its duty that the course of the Muskurra below is now, and has been for some years covered with jungle and high grass; during the severe floods of 1842, it was only slightly injured, in 1844 more severely, and the centre portion at *a a* will require heavy repairs; at *x x x* the action of the current is great, but having reached this point, the water has escaped from the slope of the Muskurra, and fallen fairly upon that of the Hindun.

59. The main objects here are, 1st, to strengthen the bund at *a a* and do every thing possible to maintain that part effectively; 2ndly, to use every endeavour to secure the bund so as to pass

water off below the shoulder A, after which the slope of the Muskurra is passed; 3rdly, in making the bund, the material is to be taken from *y y y*, so as to give the stream an inclination away from the works.

Dowlakooa Bund and Cut, No. 2.

60. The Dowlakooa work, the situation of which I have before described as being so favorable, has been by far the most successful of our Muskurra operations; the bund which is constructed of shingle, faced by fascines, &c., has for many years remained uninjured, although slightly fractured in 1844,—below this bund the bed of the Muskurra river is now covered with grass and jungle, so much so, that in 1841 when passing from Jytpoor to Ullooni, the bed of the river was not recognizable; the fractures of 1841 have been repaired and the integrity of the work has not been interfered with—the cut also is much enlarged and the tendency of the current is directly upon its mouth.

61. It is desirable that the stream should be kept at a distance from the bund, to which it naturally runs parallel; for this purpose a cut was made some years ago, which, if successful, would keep the stream considerable away from the bund. I have always endeavoured to establish a long talus or slope in front of this bund, by annually laying down long fascines made of grass, which are picketted and covered with stone, these fascines during the year rot, and give root to vegetation, grass, brambles, &c., which I consider to be of great use in adding strength and permanence to the bund. Trees of a large description are, I think, to be avoided, they are liable to be blown down during heavy winds, in which case the work suffers. The Dowlakooa bund appears to withstand the additional water that is supplied to the river by fractures at the upper or Kalowala works. I look upon the works at Dowlakooa, as the safeguard of those at Kulsea, and I am sanguine in the belief,

that with a small annual expenditure, we shall by their means, get rid of the floods from the Kalowala pass and the Kulkur rao.

Works at Kulsea.

62. The works at Kulsea consist of the masonry Dam over the Muskurra river, a Regulating bridge, and 1st class Choki, with workshops, to which is attached a model-room, forge, &c., sissoo and toon plantations are also attached to this post.

Muskurra Dam.

63. The Muskurra Dam, although it has escaped the consummation of all injuries in being washed away, has nevertheless suffered much, and undergone numerous changes since it was orginally designed. At the point where the dam is built, the slope of the bed of the river is about 9½ feet per mile. At the time of construction spring water was at the surface, and it was necessary to use wells for the foundations; the plan of these foundations was three parallel lines of wells, the front and rear being sunk to a depth of 12 and the centre to 6 feet deep, the wells in the front and rear were placed 6 or 8 feet apart, the space between being occupied by a masonry box undersunk to a depth of 6 feet—lines of 16 feet piling were driven at a distance of 10 feet from the body of the Dam to the front and rear, and the intermediate spaces were filled with broken brick, clay and refuse material.

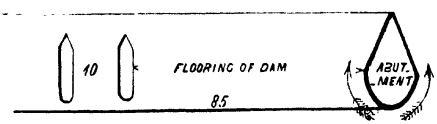
64. This Dam was completed previously to the floods of 1829, it consisted of eighteen openings, the six centre ones being fitted with gates, and the side ones being half overfalls with sleeper planks, the sill levels were as before described at the Boodhee Jumna Dam; these eighteen sluices were flanked by a masonry wall, connected with revetments extending to the right and left bank; the floods of July 1829, forced a breach through this work, carrying away a length of about 200 feet including six overfalls and upwards of 150 feet of

Floods of 1829.

the eastern revetment. The extent to which the floods of this river were in the habit of extending were evidently not understood even at this period, as although the Dam which had been so seriously injured was considerably larger than the one originally designed, it was evidently incapable of sustaining even a moderate flood. It being necessary therefore to extend the waterway, additional sluices were built, and the Dam previously to the rains of 1831, consisted of thirty openings of 7 feet each, the ten centre ones having gates and the side ones sleepers as before; in addition to this improvement however, flank overfalls of masonry were constructed so that a body of 9 feet in depth of water might pass over the Dam without overtopping the revetments—another line of 16 feet piling was driven at the tail parallel and at 10 feet distance from the former one, but the use or necessity of stronger material was not at that time thought of—the floods of August 1831, turned the west revetment and in carrying away the bank that connected the Dam with the side of the river, swept away that revetment with a portion of the overfalls on that flank—no further accident took place during 1831. The repairs consisted of removing the six flank overfalls which had been injured, and constructing a large opening of 85 feet in width, with a massive abutment on the west flank, the abutment was so arranged that if it were turned, and the bank to which it was connected carried away, the abutment would act as a cutwater, thus:—

Floods of Aug. 1831.

DIAGRAM 9.

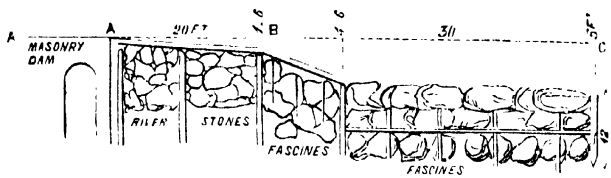


this abutment was well protected—the piling throughout, strengthened and increased, river stone thrown in between the piles, and

body of the building—the 20 feet platform in rear laid down with planks, and an additional line of piling driven in advance of the tail platform—the space between the body of the work, and the front line of piles was partly at this period laid in with river stone and cement. At this time even there were symptoms of retrogression of levels upon the tail, but of no material consequence.

65. The large opening was planned under the idea that an earthen bund, if constructed on a wide space of this sort, and built to a height equal to moderate floods, would act as an instant relief in case of heavy freshes—it was proposed therefore to raise the bund to a height of 6 feet or equal to that of the piers, so that when the water rose above this height the bund should be carried away, and a full relief given by this large opening. This acted very well, and the Dam did not suffer again until the rains of 1835. After the rains of 1834, the Dam tail was considerably exposed by the retrogression of levels: at that time the section of the tail was thus—

DIAGRAM 10.



66. In June 1835, the whole of the wooden platform opposite the eighteen centre sluices, together with the body of the Dam in rear of the ten centre ones, was carried away; the work was shaken to a small distance on the right and left, but the alignement af the front of the Dam was neither broken nor in any way disarranged. This happened during the first flood in the rains of 1835, the Dam was literally like a ship in the ocean without masts or rudder, the damage

Floods of June 1835

done was irreparable at the moment, and we could only by grass fascines and piling endeavour to protect what was left of the work—it is a singular fact but a true one, that during the rest of the season many severe floods passed over the work in the ruinous state above described, but the water having secured a passage sufficiently free did no further injury, and put us to no further inconvenience.

67. After the rains of 1835, the Dam was restored as follows —the six sluices of 7 feet wide each on the east flank were allowed to remain, and the rest of the platform between them and the large opening was divided into twelve sluices of 10 feet wide each with gates; an additional large opening was built on the west flank, and the whole platform of the Dam, including that formerly occupied by planking, was filled in to as great a depth as the spring water would admit of, with river boulders and cement, the greater portion having a pavement of brick on edge, *vide* A A B in Diagram 10. From B to C in the same diagram, or on a line of 40 feet in transverse section, frame-boxes filled with river stone, and tied together on their upper surface by sleepers, were formed in a slope of 6 feet, the whole being retained in position by lines of piles driven parallel to the body of the work, the whole of the apron in front or that between the body of the Dam and the front line of piling was laid in with boulders and lime cement to a depth of about 6 feet. At the close of the repairs of 1835 therefore, the water-way of this Dam,

Water way of the Muskuria Dam previously to the rains of 1836.

besides the eastern flank overfall, consisted of six half overfalls of 7 feet—twelve sluices of 10 feet and two large openings, one of 85 and the other of 64 feet in width—I have before noted, that the earthen bund in the 85, or No. 1 opening, was projected on a height of 6 feet, equal to the top of the piers—for the 64 feet opening, or No. 2, the bund was to be 7 feet high, so that floods rising above 7 feet should have additional relief when the earthen

bund was carried away. I had proposed a third opening of the same size as No. 2—but the results of the floods between 1835 and the present time 1844-45, have shewn that this was unnecessary.

68. In the floods of June 1842, that portion of the tail platform which was opposite No. 1 opening, was much damaged, and although the main body of the Dam escaped fracture, the foundations were exposed on the lower side to a depth of 10 feet; some of the wells had fallen in, and on the flood clearing off, when we were able to examine the work, the platform of the body of the Dam proved to be standing as it were on stilts, the intermediate soil being removed. Ever since the repair of 1835, the retrogression of levels upon the tail had been steadily advancing at an rate of about 1 foot a year, and in 1842 the difference of level between the sill of the Dam and the bed of the river at the tail, was 13 feet—that is to say, 12 inches lower than the lowest part of the Dam foundations; it was evident, therefore, that a process was going on by which the soil from between and perhaps from under the wells must necessarily be removed. The flood of 1842, in fact, in directing its full powers upon the large opening, made considerable efforts to get under the work: a deep hole was found in front, and the apron in front of the opening was shattered, but the intention of the current was best exhibited in an evident and marked depression or nulla, which extended some way up the course of the river, and which terminated on the Dam directly in front of the large opening, the tail of which had been so much injured. As this accident happened in the first floods of the season, and as the quantity of materials required for the repair was more than we could possibly collect at the time—the Dam was placed in a similar position to what it was in 1835, and again, strange to say, although successive floods passed over the work, no further injury was done. The hollows under the main body

Floods of June 1842.

of the Dam were filled in with river boulders, the front apron was strengthened and repaired, and the tail was restored to its former state, frame-boxes having been used instead of loose stone, a retaining Dam similar in every respect, but of larger dimensions to that on the Nogong river, was also built south of the masonry Dam in 1842-43. Between this period and the rains of 1844, the front of this work had been still further protected by removing all parts of the apron which were shattered, and renewing them with masonry sunk to a greater depth; additional tailwork had also been established, and other means adopted for imparting strength to the platforms.

69. The floods of 1844, which acted upon this Dam, were the collected volume of the Nogong and Muskurra rivers—after rising 7 feet in height, and taking possession of No. 2 opening, (the first time that such an event had ever occurred,) the water rose over and carried away the western embankment and turned the flank of the Dam, the force of the current having set in this direction.

Floods of June 1844.

70. In para. 35, I have described the effect that the carrying away of the Nogong Dam had upon the bed of the river, in restoring its slope to one uniform level! precisely the same occurred at the Muskurra; on the event of the embankment giving way a deposit of 9 feet in depth was thrown up on the Dam tail, and the abrupt fall disposed of. The retaining Dam flooring was also covered with a deposit of 6 feet in depth.

71. The masonry Dam suffered in a trifling degree, the western abutment of No. 2 opening, with a portion of its flooring and front apron, had settled, the former slightly, but the latter was much disarranged; a portion of the tail platform was also broken and this was the most expensive part of the repair. It was considered sufficient to restore the Dam to the state in which it was before the flood, and to re-construct the embankment without any further increase to the water-way.

Kulsea Regulating Bridge.

72. The Regulating Bridge has three spans, a centre one of 20 feet and two side ones of 15 feet each, it is fitted with gates and sleepers—its foundations consist of two paralled lines of wells 6 feet in diameter, one acting as a front and the other as a rear curtain, both piers and abutments are also founded on wells —the soil upon which they rest is a fat blue clay, at a depth of 8 feet from the bed of the Canal; this work requires no remark, it is sound and good, built of brick masonry throughout,* and situated at a point 494 feet from the Dam.

73. The Choki, 1st class, is similar to that at Nyashur, with exception to the outer rooms, which are not so high it is built of brick and mud, and is situated on a raised earthen platform overlooking the Dam and the river, with an open space to the east surrounded by the plantations. The workshops contain a carpenter's shop—forge—charcoal-rooms and godown, and a room with glass windows, in which, during my Executive charge, the models were kept. A well for drinking water is attached to these shops.

Kulsea Plantations.

74. The plantations which were established in 1829–30, are more advanced than those at Nyashur, although commenced at the same period, and the whole space is occupied by trees. Toon and sissoo are the chief varieties, but the teak, bamboo, casuarina and the pinus longifolia (a fir which grows in abundance in the Sewalik hills) have been also scattered about in places immediately under observation, as much for ornament as for use. These plantations cover an area of 51 beegahs 6 biswas.

---

* The stone slips collected at the spot for fixing in the grooves, as referred to under the paragraph on the Nyashur Regulator.

Remarks on the line from Gundewur to the Kulsea Choki.

75. Previously to commencing the 3rd section of this paper, I must go back to the Gundewur bridge, and describe my views as to the future management of the rivers which interfere with the line of the Canal between that work and the Kulsea Regulating Bridge. During the construction of the Belka and Behut Falls, cuts were made round those works, to admit of the flow of water in the Canal for the purposes of irrigation. The following diagram is explanatory of the course of these cuts, as well as of the different rivers to which I have before alluded—

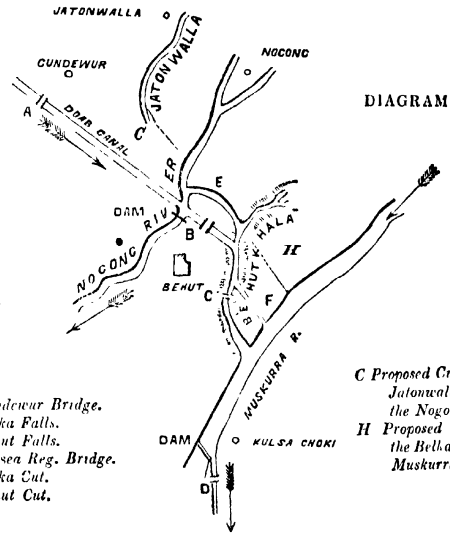


DIAGRAM 11.

A Gundewur Bridge.
B Belka Falls.
C Behut Falls.
D Kulsea Reg. Bridge.
F Belka Cut.
F Behut Cut.

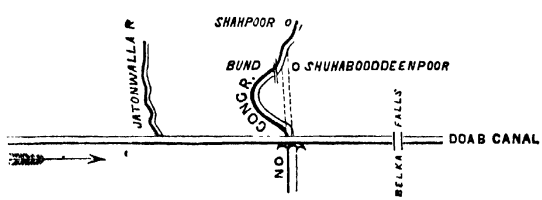
C Proposed Cut from the Jatonwalla River to the Nogong River.
H Proposed Cut from the Belka Cut to the Muskurra River.

The difference of level between the bed of the Nogong river and that of the Dam on the Muskurra, is 27 feet, the distance being 3 miles—at the time when the Belka works were under

construction, the whole of the Canal water was put through the cut E, which was (under the certainty of a natural wear) excavated on a transverse section of only 12+8, this cut was used on three different occasions, twice during the construction of the Belka Falls and once when the present Nogong Dam was building—as was expected with so much fall, the retrogression of level and wearing away of bed was enormous, the Belka cut very soon assumed the form of an enormous ravine—the Canal bed was increased in depth all the way back to the Gundewur bridge, which work, although it now has a heavy rapid upon it, was when the cut was in operation, only saved by the establishment of massive weirs laid across the bed of the Canal between Gundewur and the Nogong river. A consequence of this deepening of bed on the line of Canal opposite the Jatouwala rao was, that the rao itself, which, as formerly described, terminated its section at a distance of about 4000 feet from the Canal, entered the Canal in a perpendicular fall, this led to a retrogression of levels on its course, and ultimately to a distinct line of river being formed between the point where it formerly terminated and the Canal.

76. The situation of the Nogong Dam with reference to the present course of the river is unfortunate; the tendency of floods being towards the Belka falls, and the line of revetment on the flank of the Dam, more than to the Dam sluices; the general plan of the river and Dam at their junction may be represented thus:—

DIAGRAM 12.



the evil of this is conspicuously shewn in floods when the Jatonwala and Nogong raos are simultaneously charged with water, the two currents meet at *a* immediately under the eastern revetment, and escape by a back water through the Dam. I partly place the accident of 1842 to this cause, it is an evil of great magnitude, more especially as the revetment although well protected at its foot is built on a small section, I should recommend that a straight cut from Shuhabooddeenpoor in prolongation of the bearing of the piers of the Dam be made, as represented by the dotted lines, and a strong earthen bund be established opposite the village, so as to keep the water in the required course, this cut is at least worthy of consideration, but it must be made with due respect to the mouth of the Belka cut.

77. In the rains of 1844, the Nogong river broke through the bund at the Belka Cut head and poured all its waters into the Canal, the flood it might have been supposed would have committed a similar fracture at the head of the Behut Cut, which was also protected by a bund, which under any great increase of water ought to have broken and offered an escape down the cut, this however did not take place, the flood water rose upon the Behut bridge to a height of 12 feet, or to the cordon below the parapet; flowed over the high land on the left bank and formed a most fearful ravine close upon the work; through this ravine the flood passed without displacing a brick of the masonry, or without injuring either the bridge or the falls in the smallest degree.

78. To prevent a recurrence of flood upon these works, the following arrangements have been proposed, and will be submitted to Government immediately.

79. To avoid the meeting of the Jatonwala and Nogong floods at the point *a* under the revetments of the masonry Dam, a cut is to be made, as represented by the dotted line at G, (Diagram 11,) so as to turn the Jatonwala away from the course of the Canal, and make it join the Nogong river higher up its course.

At the head of the Belka cut, a weir of stone and frame box-work, similar to that used at the retaining Dams, is to be built, with its sill on a level with that of the masonry Dam—the flanks of this weir are to be well protected and elevated 10 feet above the sill—on it an earthen bund, 8 feet in height, is to be constructed so that floods to a height of 8 feet may pass off over the Dam—above 8 feet the bund will be carried away, and instantaneous relief given to the works.

80. The Belka cut is to be made independent of the Canal, by a bund, and an excavated line as represented by the dots H—the water will thus be carried in a new bearing to the Muskurra river, and the Behut bridge will be no longer liable to danger: by the additional improvement of the cut suggested in para. 75—the stability of the works in this neighbourhood, would be greatly increased—the levels are altogether favorable to this arrangement.

81. With reference to the increased body of water that this plan will introduce upon the Muskurra works, whenever the weir over the head of the Behut cut is opened, I may remark, that up to the year 1844—the 64 feet or No. 2 opening of the Muskurra Dam, with its bund of 7 feet in height had never been used—by reducing the height of the earthen bund on this opening, therefore to 6 feet, or to the same height as that in No. 1 opening—the use of both escapes would be insured—and in all probability this would be sufficient for the purposes required.

82. Floods like those of 1844, which may be considered as rare occurrences, and a contingency to be expected once in 30 or 40 years, it appears unnecessary to provide against; and it is questionable whether the very unfitness of our Dams to meet them, was not the cause of their preservation—the abstract of accidents during this year was as follows:—

1*st*. *Fyzabad Dam* turned on both flanks, water passing over and through earthen embankments—masonry uninjured.

2*ndly*. *Nyashur Dam:* earthern embankments on eastern

flank carried away—masonry revetment on that flank and sluices injured.

3*rdly*. *Nogong Dam*: uninjured, floods broke through the Belka cut head, and passed off in that direction.

4*thly*. *Muskurra Dam*: earthen embankment on the Western flank destroyed—masonry slightly injured.

Shewing that in every single case the excess of flood water passed off through fissures made by itself in the earthen embankments, to the instantaneous relief as well as to the preservation of the masonry works.

Road from Kulsea to the Kalowala Pass.

83. A road has been made from Kulsea to the Kalowala pass, connecting that entrance into the Deyra Doon with the high road between Suharunpoor and Behut. This line was laid out and executed by me in 1830-31, at the expense of the Canal, for the purposes of forming an open line of communication with the Ullooni, Dowlakooa and Kalowala works, upon all of which the road is directed—since the establishment of road fund committees, that of Suharunpoor has taken this work under its own management: at the present time, it requires considerable repair, no masonry drains have ever been built, and at some places the road requires raising—I would recommend that this line should be maintained in a thorough state of repair, and to secure this arrangement, that an annual estimate should be submitted by the Executive Engineer to the committee.

SECTION III.

Kulsea Choki to the Manukmow Choki.

84. This portion of the Canal suffered considerably by retro-

gression of levels after the introduction of water in 1830—the total descent in a line of about 15 miles is 66 feet. This had been remedied by the construction of the following falls or descents in masonry, all of which were built under the disadvantage of having to maintain the Canal constantly flowing during the operations :—

Nugla falls, 8 feet descent.
Bobyl ditto, 8.
Rundole ditto, $7\frac{1}{2}$.
Ghoonna ditto, $7\frac{1}{2}$.
Surkurri ditto, 4.
Hulalpoor ditto, 4.
Mekchuppur ditto, 4.

The fall from the flooring of the Kulsea Regulator to that of the sill of the Nugla Falls is 12 inches. From thence to the head of the Hulalpoor Falls, the slope of the bed of the channel intermediately between the Falls is 17-6 per mile. South of the Hulalpoor Falls to Mekchuppur, the slope is increased to 20 inches per mile.

Nugla Falls.

85. The Falls at Nugla were completed in 1834, in two chambers, one of 20 and the other of 15 feet wide, an additional 15 feet chamber having been added in 1840—a mill-room it attached with two sets of stones—the total cost, including the original building and the addition made afterwards, was 24,738 Rs. The design is similar to that of the Behut work—with a bridge of three spans of 20 feet attached—the eastern 15 feet chamber being prepared from lockage. The foundations are similar in every respect to those at Behut, the wells and floorings being similarly constructed—and the tail well protected by a wooden platform and river boulders. This work is well and solidly built, and has up to the

present time, required little repair. A 2nd class Choki is required at these works. North of these Falls, and opposite the village of Kulsea, there is on the left bank a masonry inlet for the drainage of the country, and immediately at the head of the Falls two outlets for irrigation, one situated on the right and the other on the left bank of the Canal—the latter is the supply head for the Nugla Rajbuha, a line of main water-course which crosses the Dumola river by an aqueduct, and is intended for the irrigation of the tract of country lying between the Dumola and Nugadeo rivers—its course, after extending through 14½ miles of country, terminates in the Dumola, about 2¼ miles south of the town of Suharunpoor. The stud department is provided with water from this Rajbuha. The outlet on the right bank is intended for a Rajbuha hereafter to be constructed for the irrigation of the country between the Canal and the Muskurra river, and will in all probability for the head of a connected chain of Rajbuhas extending along the whole of the right bank of the Canal—attached to the Dumola aqueduct is a 2nd class Choki.

Kulsea inlet.

Nugla Rajbuha, with Dumola aqueduct and 2d class Choki.

86. The capacity of the Canal channel from its head to the Falls at Nugla, is sufficient for a much larger supply than that now admitted into the Canal, or than that which the Canal in the southern regions could possibly hold; any quantity of water therefore may be introduced so as to give a supply to the Rajbuha heads north of the Nugla Falls, perfectly independent of that required for the wants of the Canal in its southern region. Maintaining the Nugla Falls therefore as the regulator of the supply—Rajbuhas to any extent may be constructed above it. Supposing that the water in the Jumna is sufficient for the purpose, and that the wants of the Delhi Canal would not be interfered with by such an arrangement, branch Canals of a much greater capacity than the present Rajbuhas might be made north of the Nugla Falls, so as

not only to extend the means of irrigation far to the right and left, but to lead to the establishments of corn mills, or power for other machinery throughout the lands that came under its influence.

Bobyl Falls.

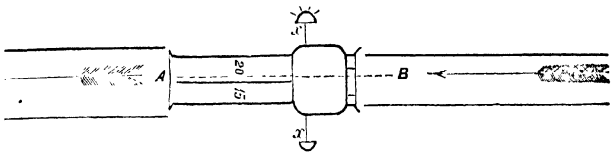
87. The Bobyl Falls are similar to those at Nugla, were built at two different periods and under the same circumstances, and cost 17,746 Rs. The foundations are similar in every respect, and soil the same—a red sandy clay. There are no corn mills at this work. I consider the whole sound and stable—there are two masonry heads for irrigation above these Falls on the right and left bank—a 2nd class Choki is also required here.

Rundole Falls and 2nd Class Choki.

88. At the point where the Rundole Falls are situated, a bridge of 3 spans, one of 20 and two of 15 feet each, built previously to 1830, existed. This bridge was built with curtains and pier foundations sunk to a depth of $7\frac{1}{2}$ feet, it was in good order and in every way efficient. The proposed Falls therefore were designed as a separate work at a distance of about 100 feet south of the bridge, which it was not worth while to alter for the mere sake of uniformity. The Falls are in every way similar to those formerly described, with the exception of their being unconnected with the bridge, built at two different periods, viz., in 1834 and 1840, and cost 17,750 Rupees. The foundations and work in general are secure; there is however less back water upon the chambers at these Falls than there is at those before described—and consequently much more action of current upon the timber platform at the tail—this action is not dangerous, but the tail must be carefully looked after, and examined at periods when the Canal is laid dry.

89. The lining out of these Falls is, with reference to the position of the bridge, a blunder—the intention of increasing the waterway by a second 15 feet chamber, was overlooked when the work was laid out in 1834. The Falls, which then consisted of a chamber of 20 and another of 15 feet in width, were placed centrically on an alignement, AB, in prolongation of the centre of the bridge, thus:—

DIAGRAM 13.



it is evident therefore that in making an additional 15 feet chamber on the right to correspond with that on the left bank, there is an awkwardness of design, which although of no consequence to the flow of water, nor to the mere demands of the Canal, is a disfigurement. There are two heads for irrigation above the Falls as shewn at *x x* in the above diagram. The Choki, 2nd class, is similar to that at Gundewur.

Malaheeri Bridge.

90. The Malaheeri Bridge. situated south of Rundole, is a plain structure of two spans of 25 feet each, founded on wells, sunk to a depth of 12 feet. There is nothing to remark upon here, but that this is the only bridge on the Doab Canal without floorings or counter-arches. It was completed by Mr. Pigott in 1837, at a cost of 3,273 Rupees.

The Ghoonna Falls and Mill.

91. The Ghoonna Falls were commenced in July 1830, and

were the first works of this description which were built—the soil is almost pure sand, and the difficulties of maintaining a temporary rapid, round the work during their construction were by far greater than we met with elsewhere; at that time moreover, neither I nor the Europeans under me were experienced in difficulties of this sort. The design of the work is nearly similar to that for the Nugla Falls, with mills attached, and differs from it only in some slight deviation in the elevation of the bridge. The Ghoonna Bridge as constructed previously to 1830 consisted of three arches —similar to that at Rundole—its foundations were also the same and sunk to a depth of $7\frac{1}{2}$ feet—these foundations were taken advantage of in the design for the Falls, but the superstructure was removed. The plan that I adopted for the foundations of the Falls was to sink a line of 6 feet wells parallel to and at $4\frac{1}{2}$ feet distance from the rear foundation wall of the bridge—these wells were sunk to a depth of 11 or 12 feet, and were protected by piling as shewn in Diagram 7. This line of wells was intended as a protection to the lower foundations from the action of springs. At the tail of the Falls another consecutive line of wells, 8 feet in diameter, was sunk to a depth of 12 feet, and also protected by piling—the intermediate space between this upper and lower line of wells consisted of wells (or neemchuks rather) under each revetment placed at a distance of 4 feet apart, and similar lines centrically placed under the chamber floorings,—these neemchuks were sunk to a depth of 4 feet and the whole was connected by arches, there were however no counter-arches to the chambers but a masonry flooring was laid in to a depth of 2 feet, the upper part of which was brick-on-edge. In 1840, an additional 15 feet chamber was built, and opportunity was taken to strengthen the floorings as much as possible. It having been convenient when the work was originally constructed to build the mill house on the flank revetment of the 20 feet chamber, I decided on extending the water-way and giving five additional feet in width to the Falls—the left flank revetment therefore of the old

15 feet chamber was removed, and that chamber increased in width to 20 feet, the new 15 feet chamber or lock with its two revetments were then constructed on foundations, counter-arches, &c., similar in depth and strength to those at the Nugla and other Falls, in the building of which we had been gradually obtaining experience. The plan of floorings which was adopted in the work which was first built is probably to be objected to. In 1833, almost immediately after the Falls were built, it was found impracticable to maintain the Canal in its course round the bridge from the wear and tear upon the temporary rapid, and we were necessitated to turn the stream over the masonry work; from some cause or other, possibly from the masonry not being indurated, and the rush of water above acting upon it, but perhaps from the action of under-springs, the flooring at the foot of the ogee of 15 feet chamber was blown up, the injury did not extend itself, but was limited to a hole of about 13 feet in length on the full width of the chamber. The repair of this was undertaken by Lieut. Napier in August, September, and October 1833, the force of the under-springs was such that trifling as the injury appeared, the remedy was a difficult one; after devising numerous expedients, caissons were sunk and filled with brick masonry and concrete, the latter being well rammed; over these thick floorings of brick laid flat, but with the interstices carefully covered, were fixed, this was then covered by brick-on-edge, and over the whole a wooden platform secured, so that the action of the water could not disarrange the masonry—this repair was quite successful. The floorings, however, of the two chambers above referred to are constantly giving trouble, require constant looking after, and it is to be feared that the violence of these under-springs, are acting injuriously in removing the subsoil from under the foundations. In other respects the work is good—built of brick masonry with stone lime, and soorkhi cement. The situation of these

The Ghoonna Falls have a total breadth of 55 instead of 50 feet, as at the other Falls.

falls is bad, they are built on the immediate approach to a bend in the course of the Canal, which has led to the demolition of the roadway on the left bank, and will ultimately (unless means are taken to stop the evil,) do much further damage. A 2nd class Choki is here also required for the lockage establishment.

Ghoonna Outlet.

92. The Ghoonna Outlet, which is situated on the left bank above the Falls, is used for irrigation, it is situated at the head of drainage connected with the Pandhoi Nulla; an aqueduct is thrown over the reservoir of the Ghoonna Outlet, connected with a line of irrigation from above the Rundole Falls.

Putni Rajbuha.

93. On the right bank and just above the Ghoonna Falls is the head of the Putni Rajbuha, a water-course dug at the request of Goolab Sing, a banker and resident at Jugaderi, for the purposes of taking a stream of water to the town of Putni; the object would have been much more efficiently attained by taking the head from above the Nugla Falls, but Goolab Sing appears to have preferred the spot which he selected near Ghoonna, as nearer to his own estates, and suspecting in all probability, that had the supply been taken from Nugla, his lands would have been at the tail of the water-course, and as is usual in similar cases (when years of drought occur,) been liable to constant interruptions to the flow of water. The present line, however, is an expensive one, owing to its having to pass a tract of very low country, which is passed by a long line of earthen aqueduct. After filling a masonry reservoir opposite to the eastern gateway of Putni, it passes onwards towards Teeri. The total length is about 7 miles—the drainage of the low land which is crossed by this Rajbuha, is effected through an

opening left in the earthen causeway, which opening is passed by the Rajbuha, over an aqueduct made of sheet-iron supported on masonry piers—the space between the bed of the water-course, and the surface of the country not being sufficient to admit of arches.

Surkurri Falls.

94. The Surkurri Falls have a descent of four feet only, without a bridge, the design in other respects is similar to that before described, viz. a centre chamber of 20 feet, with flank ones of 15 feet wide each—the work is massively built, and founded on wells on the same plan and depth as at Nugla, the chambers are counter-arched, and tail well protected. The difficulties of constructing this work were great owing to the sandy state of the soil, and the expense was proportionately heavy—the total cost was 16,536 Rs. These Falls were completed in 1810. Between the Ghoonna and Surkurri Falls there are three masonry outlets for irrigation, one on the right and the other on the left bank immediately at the head of the Falls, all these works are to be depended upon. A 2nd class Choki is here also required for lockage establishment.

Surkurri Bridge.

95. The Surkurri Bridge is about a mile south of the Falls, it has a centre archway of 20 feet, with side ones of 10 feet wide each. Both piers and abutments are founded on wells 6 feet in diameter, sunk to a depth of 16 feet, resting on sand: it is counterarched and the curtain walls to the front and rear are sunk to the depth of 4 feet—this work is sound and has required little repair—the Choki, 2nd class, is situated on the right bank, and is similar in every respect to those formerly described—there is a small masonry outlet for irrigation near this bridge.

96. Between the Surkurri Bridge and the Falls at Hulalpoor—the heads of the Pandhoi Nulla are passed on the east, and the low land at Duthowli on the west of the Canal—to each of these, masonry works have been adapted—Colonel Smith's original project designed the Pandhoi as the receptacle for escape water during floods; a masonry outlet of two 6 feet openings was constructed on the Canal bank, and a cut made to the nulla for the purposes of escape—it was also determined that these lines of escape nulla should be converted into lines of irrigation, by throwing masonry Dams over their courses, with embanked reservoirs, so as to give head water, and facilities to the cultivators in obtaining water for their fields—I defer all remarks on the results of these arrangements as a separate chapter will be devoted to them—and shall continue my description of the works at present existing.

Pandhoi Outlet.

97. The Pandhoi Outlet, which was constructed previously to 1830, is well and solidly built—it is floored with masonry, and its foundation consists of curtain walls; that, towards the Canal front is laid to a depth of 4 feet and rests on soil with kunkur; the tail curtain rests on wells sunk to a depth of 18 feet, well protected by piling and kunkur, its sluices were originally fitted with both gates and sleepers, but the former has given way to the latter, partly owing to the impossibility of protecting iron work, at a distance from a Choki post from thieves, and partly from the sleepers being more readily used by the Native Establishment.

Pandhoi Dam for Irrigation on the Pandhoi Nulla.

98. At a distance of about $1\frac{1}{4}$ miles from the outlet head, a Dam similar to the outlet itself is constructed across the bed of the Pandhoi Nulla, this work is called "the Pandhoi Dam," and

is situated between the villages of Shahpoor and Sunkullapoori—connected to this by revetments of masonry are outlet heads, that one on the right bank being the head of the west Suharunpoor cut which after a course of five miles returns its water to the Canal through an inlet near the Kirsunni Choki—that one on the left being the head of the east Suharunpoor or the Botanical garden cut which after a course of $3\frac{1}{2}$ miles falls into the Pandhoi river, after passing through sets of mills for corn grinding. These cuts are crossed by masonry bridges at all the principal roadways—and are planted with trees throughout their whole course.

99. The Pandhoi Dam is in every way a good and sound building—its foundations are massive and laid upon wells—attached to it is a 2nd class Choki similar to those before described; the silting up of the course of the nulla between this point and the Canal leads to constant expense and is very troublesome, there appears to be no remedy, but patience, and the hope that in the course of time the Canal water may be purer; this evil however has decreased greatly within the late few years, and will, I have no doubt, ultimately be greatly modified. A straight line of road connects this Choki with that at Hulalpoor on the main line of the Canal.

East Suharunpoor Cut.

100. The East cut requires clearing out occasionally especially at the head and near the Dam—at a distance of $2\frac{1}{2}$ miles from its source it enters the Suharunpoor Botanical garden, close by the Hurdwar gate, near which a corn-mill has been built:* the garden

* Built in 1831, at an expense of Rs. 420-11-3—the fall of water is about 8 inches: and machinery with an under-shot wheel was originally adapted; the native millers however were so constantly in the habit of disarranging this machinery, that it was found convenient to replace it by the native corn-mill—this works very well, by maintaining the surface of the water in the Dam on a high level.

is entirely irrigated by the cut, which previously to forming an ornamental sheet of water near the conservatories, passes over a fall, and adds greatly to the beauty and appearance of the grounds —the water escapes to the south and passes through mills built on the slope of the valley of the Pandhoi. At two principal points on this water-course, ghats have been constructed attached to bridges—the channel being built of masonry, with steps down to the water on each side; on one of the principal crossings between Suharunpoor and Hurdwar the length of double ghat thus constructed is 120 feet, offering great accommodation to travellers and pilgrims *en route* to the Holy City. The mills which as I before said were built on the slope of the valley of the Pandhoi Nulla, were partly constructed previously to 1830 and completed at different periods afterwards—the slope of this valley is impregnated with land-springs, which were necessarily increased by the introduction of the line of water-course, the head water of the mill Dam being 13 feet higher than the floorings of the escape! Shortly after the building was finished, an accident happened to the tail at the point where the escape water reached the Pandhoi, leading to a slight settlement to one angle of the building and to the sluice floorings under that angle. To this fracture the final demolition of the building may be placed—in 1844 the mills having been reported upon, as sound, and in good order only a few days before, tumbled in, the foundations of the centre wall having given way. The ruin was so complete, that I deemed it advisable to remove the whole, and re-construct new mills on entirely new foundations.

Corn-mill, Botanic garden.

Suharunpoor mills.

101. The merits of the common boring apparatus, without the use of tubes, are doubtful. When the foundations of these mills were under construction, the borer was used in sundry places, and the results shewed that a stiff blue clay was to be found at depths varying from 5 to 8 feet. Wells or cylinders were therefore built

to a height of 6 feet, and undersinking commenced ; after working through from 2 to 4 feet, the same clay which we had found at a greater depth with a borer, shewed itself, the clay appeared sufficient for a foundation, and it was used as such, the upper portion of the cylinders was therefore removed, and the superstructure was completed. On clearing out the foundations after the accident of 1844, the wells under the centre wall were out of the perpendicular, the others were straight, but both in the wells and in the lower parts of the walls, where the brick-work had been acted on by the springs, the whole of the mortar or cement had been removed ; the surface under the old foundations exhibited springs rising up in bubbles, and that sort of soil which is vulgarly called 'slush,' the masonry, which away from the influence of springs was of a most superior description, and the wells and every part of the building appeared to be well and massively built.

102. The cause of this failure was a want of depth to the wells in foundation : the accident alluded to in para. 91 having in causing the settlement to the floorings of the sluice channels opened crevices and outlets for sand, the action of the land-springs constantly at work upon the substrata, upon which the wells of the centre wall were built, had apparently undermined the wall, by gradually ejecting the sand and clay, upon which it was founded. The new mills, which are by this time I imagine nearly built, are planned with walls sunk to a depth of 10 feet, no centre wall is admitted into the construction, and the supply of water is introduced to the mill shoots, through a long line of masonry channel, so as to remove the influence of the head water upon the natural landsprings to a considerable distance from the building.

Mill Bridge—Pandhoi River—Suharunpoor.

103. The Bridge on the Pandhoi near the mills was built by private subscription many years ago, it has lately been much in-

jured by floods, an increase of drainage having been thrown into the nulla north of the bridge, through the Dholi Khal, a tributary, which has been artificially connected with the drainage to the west of the town of Suharunpoor.

104. As the Canal water which falls into the Pandhoi river from the mills is at present lost—and as the Pandhoi itself is a perennial stream, it was my intention, had not other matters intervened, to have examined the Dumola river, (into which the Pandhoi falls, and which also is perennial), south of the bridge, with reference to the construction of a Dam over its course, so as to use the collected waters of the Dumola and Pandhoi, for irrigating the lands between the Kirsunni and Hindun. The river is such an enormous one during floods, that the expense in all probability of constructing a Dam would be against the undertaking; but nevertheless the project is worth examining.

West Suharunpoor Cut.

105. The West Suharunpoor Cut deserves no particular remark; the late formation of the Mekchuppur Rajbuha, which crosses it at the high road between Suharunpoor and Kurnaul, has connected it with that line of irrigation. The channel of the West cut requires annual clearance, especially from young sissoo trees, which establish themselves with great rapidity on the line—near its junction with the Mekchuppur Rajbuha there are numerous teak trees which appear to flourish.

Duthowli Inlet.

106. The Duthowli Inlet has three openings, a centre one 6 feet and side ones of 3 feet each; owing to the alteration of levels in the Canal bed, and the raising of the sill or flooring of the Hulalpoor Falls, this work only acts for the purpose of inlet when

the Canal is dry. This is remedied however by a much more efficient method for draining the low land at Duthowli, by taking advantage of the great declivity in the surface of the country, and by a ditch or escape dug parallel to the Canal (which ditch acts also as the Canal boundary,) which admits of the water passing off at the Alumpoor inlet, a masonry building situated on the right bank near the bridge of the same name. This project was laid out by me formerly, the channel excavated, and a bridge built at the Hulalpoor bridge ramp : it did its duty well, but latterly it has been neglected, and the cultivators by throwing bunds across for irrigating their fields, have completely annihilated it, as a drain from Duthowli.

107. As the low land at Duthowli is a great disfigurement to the country and is in all probability a cause of sickness, I would recommend, that the maintenance of the line of escape should be insisted upon, and that when opportunity offers, a series of levels should be again taken, commencing at the lowest point of the jheel ; that the cut should be cleared out, and if necessary widened, and severe penalties attached to those who in any way interfere with the channel. In all the line from the Surkurri Falls to the Pandhoi Outlet, the percolation of water through the Canal banks is more or less observable, especially *near* the banks, where the surface has been removed for bank repairs, &c.

Hulalpoor Falls and Choki, (2nd Class.)

108. The Hulalpoor Falls are built at a short distance from and south of the bridge with which they are connected by a ghat or step'd revetment. The bridge consists of two spans of 25 feet each in width—and the falls, having a descent of 4 feet, are precisely similar to those at Surkurri—the foundations are laid in good stiff clay—are massive and built of very superior brick masonry, irrigation drains are constructed on the right and left

revetments, between the bridge and the heads of the falls, there is also a small outlet for irrigation on the left bank immediately above the Choki which is situated close to the bridge. There is considerable afflux on this bridge owing to the proximity of the falls, an evil which reduces the value of the revetment heads for irrigation. On the western ramp of the bridge is a masonry drain connected with the Duthowli drainage before alluded to. Attached to this post are toon and sissoo plantations. The whole of these works are in good order. Between the Hulalpoor Choki and that at the Pandhoi Dam, a road was formerly made to connect the two posts, this road requires raising at some points, and would be improved by masonry drains. The Hulalpoor bridge is on the high road between Suharunpoor and Umballa. These works were built in 1841 at a cost of 10,202 Rupees.

Adumpoor Bridge.

109. The Adumpoor bridge was built previously to 1830; it consists of a centre arch of 20 feet wide, with a circular arch on each side of 6 feet diameter—the water-way is much confined at this bridge, the level of the bridge floorings requires to be lowered, and the time will soon arrive when the necessity for re-constructing the water-way on a similar scale to that of the new Hulalpoor bridge will shew itself—the sooner that this improvement is effected the better!—there is at present a very heavy rapid on the tail and the cutting away of embankments is great—the present bridge however, although with foundations of only $2\frac{1}{2}$ feet deep, is perfectly safe, if proper attention is given to the rapid at its tail—the building is massive and strong.

Adumpoor Inlet.

110. The inlet on the right bank immediately above the

bridge, is in good order, it consists of one opening of 6 feet wide, it acts as a relief to the Soorya Tulao, a large tank or hollow close by, as well as to the admission of flood water from Duthowli.

Mekchuppur Rajbuha.

111. Between the Adumpoor Bridge and the Mekchuppur Falls the Mekchuppur Rajbuha leaves the Canal on the left bank, this line of water-course after extending over a length of 15 miles, terminates in the Kirsunni river near Chukwali and Shoudaspoor; a feeder for this Rajbuha will leave the Canal near Ruttunkheri bridge, crossing the Kirsunni river by a masonry Dam, the latter work has been authorized to be constructed at the expense of the Government. Opposite the Mekchuppur Outlet is a small masonry drain on the west bank, which is, I believe, deserted, it is out of repair at present.

Mekchuppur Bridge and Falls.

112. The Mekchuppur Bridge and Falls are similar in every respect to those at Hulalpoor, with the exception of the revetments connecting the bridge with the falls, which at the former are much longer, this is a main line of communication during the Hurdwar fair especially, and the ghats are much prized by the community. The evils arising from afflux on the bridge are here also very prominent; the bed of the Canal owing to the rapid current between the bridge and the head of the falls requires to be looked after, and every opportunity ought to be taken of protecting it by masses of kunkur. Irrigation outlets are built in the revetments in the same way as is practised at Hulalpoor—these act also as inlets during the rains. As heads for irrigation these outlets would have been more advantageously situated above the falls where they would have derived all the benefits of the afflux;

but at the same time other masonry works would have been required to conduct the water across the high road. These works were built in 1841 at a cost of 10,523 Rs. A second class Choki is required at these falls for lockage purposes.

Manukmow Bridge and First Class Choki.

113. The Manukmow Bridge is built on the same model as that at Adumpoor, the rapid at its tail is not so observable. But the same remarks which I have made on the Adumpoor bridge are equally applicable to this. The bridge was built previously to 1830, the work is sound and good, but the water-way is too contracted. The first class Choki which is on the east bank near to the bridge is constructed on the same plan as those at Kulsea and Nyashur, and requires no remark. Immediately above this bridge on the east bank, is a small drain for inlet, and immediately below and on the same bank an outlet head which is connected with the circular tank in the Manukmow yard.

Manukmow Yard and Workshops.

114. The Manukmow Yard is a quadrangle surrounded by thatched buildings built of sun-dried brick—in the centre of the quadrangle is the Executive Engineer's office. During the time that Col. Smith was carrying on the works, in conjunction with those under the Garrison Engineer at Dehli, this yard was the depôt for all the timber and workshops attached to both departments—since that period however it has been considered merely as the Head Quarters of the office and establishments, attached thereunto, for whom ample cover is offered. Attached to the yard is my own estate, garden, &c. Between the yard and the Canal is a mango graft plantation covering about 5 acres of land.

SECTION IV.

Manukmow Choki to Abba Choki.

115. In continuing the description of the works from this point I shall omit the smaller class of outlets referring the reader to Appendix D., which contains a list of all the outlets and inlets.

Kirsunni Outlet and 2nd class Choki.

About a mile below the Manukmow post, are the Kirsunni Outlet and Choki (2nd class) situated on the left bank of the Canal. The outlet has two openings of 6 feet wide each, and is similar to that at the Pandhoi head—its foundations are built in good soil, and the structure is sound. This was intended in the original project as an outlet for escape water during floods—and the Kirsunni nullà, at the head of which it is situated, was as in the Pandhoi before described, proposed to be used for the purposes of irrigation. The Kirsunni nulla after extending through a course of about 80 miles, and passing close by the towns of Rampoor, Thanna, Julalabad, &c., joins the Hindun river at Burnawur—like all the Doab lines of drainage unconnected with the mountains, it commences in a series of low jheels and rice land, and terminates in a deeply depressed bed, passing through an extensive valley. It was proposed to throw masonry Dams over this nulla at different points as far south as Julalabad. Previously to 1830 a Dam of this description with a Choki was built at Rampoor, shortly afterwards two other Dams, one at Chidbunna and the other at Nulhera were built, to each of these works a corn-mill was appended. The evils attending on this arrangement were apparent very shortly after the Dams came into operation: the quantities of silt which they maintained led to the total destruction of the Kirsunni outlet, as an escape for floods: the constant flow of water required for the purposes of supplying the Dam reservoirs, led to such extensive deposits of silt, that al-

though it might have been worth the expenditure required to keep the channel clear, time and labor could not be afforded—it was plain, that simple as it appeared to be to take possession of the channel of an old nulla, and by throwing bunds over it, provide the means for irrigation; it would be not only cheaper, but infinitely more advantageous, to make cuts from the main line of Canal, which running parallel to the course of the nulla, was in every mile of its length gaining increased advantages in a more elevated bed. This led to the Rajbuha system which will be hereafter described. The Dams at Chidbunna, Nulhera and Rampoor have done good service as heads for irrigation nevertheless, but the mills at the two former places have been abandoned.* To complete the line of the Kirsunni, as a branch for irrigation, a Dam has been built at Bunhera, a place situated about four miles north of Julalabad -this work has heads of irrigation attached to it by lines of revetment, as at the Pandhoi Dam—it consists of three openings of 10 feet each, is founded on wells and boxes, and is strong in every respect—as this work is a main outpost for irrigation, a Choki building is attached, the inner dimension of which is 22 × 16, built of pukka brick and mud, with a flat roof. The Bunhera Dam is intended to catch all water that passes down the Kirsunni, and deliver it off in channels of irrigation to the right and left -that on the right has been completed under the name of the Julalabad Rajbuha, a line that is connected with other water-courses, which will be explained hereafter.

Ruttunkheri Bridge.

116. The Ruttunkheri Bridge is situated a short distance be-

* These mills merely consisted of masonry channels, and had no superstructure, they were stopped by the silt deposits. The Rampoor mill was built in 1833, at an expense of Rs. 771-6-6—it does not work satisfactorily, partly owing to silt, and partly to back water, arising from the Escape Channel having been originally constructed on too low a level.

low the Kirsunni Outlet, on the main line of the Canal—it is built precisely on the model of the Adumpoor Bridge, and its water-way is much contracted, the floorings (as in the case of that bridge also) require modification—a heavy rapid exists on the tail of this bridge.

Reeree Bridge and Falls.

117. As at Hulalpoor, and Mekchuppur, the old Reeree bridge, which was similar in form and water-way, being constructed on the plan of that at Adumpoor, was removed, and in its place a bridge of two spans of 25 feet each was built—the falls are situated 100 feet south, and the whole work is precisely the same as those at Hulalpoor and Mekchuppur, with the exception of the connecting revetments which have been omitted—I have no remark to offer on these works, they are, I believe, sound in every respect—a Choki 16 × 10 is attached, built of pukka brick and mud. There is a hole or tank situated between the left bank of the Canal and the village of Reeree, which I partly filled in from the excavation at the falls, and I have endeavoured to complete this very desirable work, by carrying a water-course through it, so as to warp it up with silt—this latter arrangement has not been very successful up to this time, but I have no doubt that it will be so eventually ; it is most desirable to get rid of this hole with its reeds and stagnant water.

Balpoor Falls, Bridge and Second Class Choki.

118. The Balpoor Falls are in every respect the same as at Reeree, there is something defective in the arches of the bridge, which have lately exhibited an hair crack through their crown—the building in other respects is, I believe, sound, and the falls well protected. There is a Choki here, 2nd class, similar to that

at Rundole. Between the Reeree and Balpoor Falls, the Islamnuggur Rajbuha leaves the Canal on the right bank—this watercourse has been excavated at present on a line of 5 miles, but is to be extended hereafter.

119. From the sill of the Belka to the lower flooring of the Mekchuppur Falls, the levels of the Canal bed have been regulated on slopes described in para. 84: from thence to those at Balpoor, the slope per mile has been regulated at 23 inches. With exception therefore to that portion of the Canal lying above the Belka Falls the levels may be said to be completed as far south as Balpoor. From Balpoor, the effects of silt upon the bridges will be shewn by reference to Appendix B., shewing the state of high water in the different bridges from Myhee to Bynswal, as taken by me in 1843.

Myhee Bridge.

120. The Myhee Bridge has one span of 31 feet, 3 feet of which is occupied by a towing path—this work was completed in 1836, at a cost of 1,132 Rupees—there was some great neglect in removing the centering of this arch either too suddenly, or at an improper time, the form of curve was a semi-ellipse described on its two foci, the half conjugate axis being 7 feet—in removing the centering, this axis has been so much lessened as to be perceptible to the eye, and there are cracks both through the haunches and crown of the arch: as these have existed ever since the year 1837, and don't appear to increase, the bridge may, I fancy, be considered secure. I believe, in other respects, that the work is sound, it is built on curtains and counter-arched.

Ghusouti Outlet and Rampoor Rajbuha.

121. Further on, on the east bank, is the head of the Rampoor

Rajbuha, commencing at the head of the Ghusouti Outlet, a line connecting the Canal with the Dam at Rampoor—this work is in good order, the flooring ought to be 12 inches above that of the Nowrungpoor Bridge.

Nowrungpoor Bridge.

122. Nowrungpoor Bridge, a work built previously to 1830—its water-way consists of a centre 20 feet span, and side holes of 5 feet in diameter—a sound strong work, but too small for the passage of the water, it is built like all those at that period, with counter-arches, masonry curtains, &c., the depth of the curtain in the centre of the counter-arch is 24 inches—between the Myhee and the Nowrungpoor Bridge, the banks have been slightly raised to meet the silt deposits, but these are now rapidly disappearing since the upper falls have been completed.

Rampoor Bridge and Second Class Choki.

123. Rampoor Bridge—similar in every respect to that at Nowrungpoor with the exception of a wider road-way—sound and good, but water-way contracted—between this and the last bridge, the banks have been greatly raised. Owing to this rise of embankment, to meet a proportionate rise in the surface of the Canal water, the Choki which was built of mud, and was within 20 feet of the edge of the water, was constantly getting out of order—the moisture acted upon the foundations, and the superstructure bulged to such a degree at last, that it was necessary to pull the building down. The new Choki ought to be built at a greater distance from the Canal ; but as the silt which is deposited in the Canal bed at this bridge is rapidly moving forward—the annoyance of high water will not continue for a very long period —close to the Choki, an outlet for irrigation exists, which would

eventually act as a feeder to the Rampoor Rajbuha, the line is tortuous at present, and would require to be improved and laid down on a fresh set of levels.

Kullurpoor Bridge.

124. Kullurpoor Bridge—the same as at Nowrungpoor, sound and good, the centre arch has been injured by rafts, a remark that applies to all bridges from that at Nowrungpoor downwards—water-way contracted.

Abba Bridge and First Class Choki.

125. Abba Bridge—the same as at Kullurpoor—to this work also similar remarks are applicable—both at Kullurpoor and Abba, the silt deposits are very heavy, as will be observed by the high-water mark of 1843, *vide* Appendix B. From Nowrungpoor downwards, the necessity of raising the Canal embankments very soon exhibited itself after the Canal was opened in 1830—between Kullurpoor and Abba, they have been raised at least 8 feet, and the water at this moment may be said to be carried over the country in an earthen aqueduct. Owing to the excavation made by otters and other vermin, as well as to the carelessness of the Zumeendars in establishing their water-course heads, this line was constantly suffering from accidents arising from breaches in the banks. On the west of the Canal an extensive hollow, under the name of the Unuthmow Jheel, was occasionally flooded, and the water, extending as far as the eye could reach, led to much damage to the crops—it was therefore found necessary to remove all water-course heads from the line between Kullurpoor and Abba, and to establish at Kullurpoor outlets for main lines or Rajbuhas—that one on the east bank has been in operation for many years—it extends to a distance of seven miles, and arrangements are making

for prolonging its course by an aqueduct over the Kirsunni, so as to give the benefits of irrigation to the left bank of that river. The Rajbuha, on the west bank, has not yet been commenced upon.

Drainage, Unuthmow Jheel.

Still further to protect the country from the breakage of banks—a cut has been made from the Unuthmow Jheel, to the west, through land which separated it from the Kattha Nulla, the levels are peculiarly favorable to the undertaking, and as the bed of this cut has been projected from the lowest part of the Jheel every facility for the rapid escape of water will be attained.

126. I consider that the maintenance of this cut, from the Unuthmow Jheel, is of the greatest importance, and I would suggest that no opportunity should be lost of inspecting it, and seeing that its channel was not in any way choked up. On the main line of Canal, no Zumeendar's water-course heads ought, on any consideration, to be established at points where the surface of the Canal water is *above* the level of the country.

127. When the silt is sufficiently cleared out from the Canal bed between Kullurpoor and Abba, I would recommend that a bridge should be built at the point where the Unuthmow Ghat is now situated, so as to admit of the cultivators at Unuthmow getting to their fields, at present the estate of Unuthmow is divided into two portions by the course of the Canal. The bridge would also be convenient as a line of communication to Dhakadai and other villages in that neighbourhood.

128. Between the Balpoor Falls and Abba the declivity of Canal bed is very considerable, and hereafter descents of 4 feet each will be required both in the neighbourhood of Rampoor and Kullurpoor, supposing that the silt deposits are removed.

Abba First Class Choki.

129. The Abba Choki is 1st class, similar in every respect to

those before described : owing to the action of moisture upon the foundations of this choki, arising from the rise of the surface of the water in the Canal, this building has on two occasions required repair—its flooring and walls have been raised $3\frac{1}{2}$ feet to meet the rise of the embankments—at present however it is in good order, and I believe in a perfect state of repair. A main line of road has been constructed at the expense of the Canal, between the Abba and the Bunhera Choki (on the Julalabad line of irrigation) the road is about 7 miles in length and requires masonry drains : since the establishment of the Suharunpoor Road Committee, this work has been placed under its management.

SECTION V.

Abba Choki to the Berkheri Choki.

130. In advance of Abba the line of Canal (before described as that of the old Shamli nulla) is very tortuous, and the silt deposits very heavy, the raising of embankments therefore throughout the whole of this section has been extensive ; for the actual height of high water in 1843, in each of the bridges I must refer to Appendix B., from which a perfect idea of the deposits may be formed by observing that the tops of the original embankments were 6 feet only above the original bed of the Canal, the section of the original Canal being shewn by the green lines.

Nynpoor Bridge.

131. In advance of the Abba Choki is the Nynpoor Bridge with a water-way consisting of one span of 18 feet in width, with circular arches on each side of 5 feet in diameter—with exception of the brick work of the arch being injured by rafts passing under it the work is sound and good—its foundations are on curtains

with counter-arches, the depth of foundations 2 feet below the centre of the counter-arch, the soil upon which they rest is a hard clay.

Bahmunmajra Bridge and Second Class Choki.

132. The Bahmunmajra Bridge is exactly the same as that at Nynpoor, and requires no remark—a 2nd class Choki, similar to that at Rundole, is situate on the right bank near the bridge.

Madhoopoor Rajbuha.

133. Between this last bridge and that at Bursa the Madhoopoor Rajbuha leaves the Canal on its each bank—after extending over a course of $6\frac{3}{4}$ miles it falls into the Julalabad Rajbuha near the village of Umbyta.

Bursa Bridge.

134. The Bursa Bridge was built on the same model, and at the same time as that at Myhee, and by the same overseer, Serjt, Petrie, the arch has settled at this bridge, and the south-west pillar upon which the wing wall terminates has, by settling, given an ugly crack on the wing wall—in other respects the work appears to be good—the size of water-way is well adapted to the wants of the Canal at this point, and the height of the crown of the arch from the present surface of the water is sufficient for the passage of rafts without interfering with the brick work. This work which was completed in 1835 cost 928 rupees. The soil upon which the foundations rest, as in every point of the line of Canal in the Shamli nulla, is good clay.

Poojna Bridge.

135. Poojna Bridge and 2nd class Choki are built on the same model as those at Bahmunmajra, and require no remark.

136. North of the Poojna Bridge and on the west bank, a Rajbuha was formerly commenced, but stopped for want of funds, and from the Zumeendars appearing to be indifferent about its construction—the lining out was bad, and the work was deserted; the site of the head however is good, and the line on an improved course might herçafter be taken advantage of.

Berkheri Bridge and First Class Choki.

137. The Berkheri Bridge and 1st class Choki are situated about 2 miles south of Poojna. The bridge has a centre arch of 18 feet span, with circular arches on each side of 4 feet in diameter—the foundations are similar to those before described—the arch of this bridge is almost destroyed by rafts, and a portion of the parapet on the upper stream face has fallen down—neither this nor the other bridges on this part of the Canal have been repaired by me from circumstances which I shall explain in my remarks appended to Section VI. The 1st class Choki is similar to those before described—a pukka well with covering is attached to this Choki—as well as a mango graft plantation of the same size as that at Manukmow.

Road passing over the Berkheri Bridge and connecting the Town of Teetroon and Julalabad.

138. Berkheri is a small village, which from want of roads was formerly completely isolated—the want of cart roads was a great inconvenience, and during the rains especially, the village was completely cut off from the market towns in the neighbourhood—since the establishment of the Road Fund Committee, a good road, well raised, has been completed from the Canal bridge on the west to Teetroon, with masonry drains—and on the east a similar road to the town of Julalabad; this latter line requires a

few masonry drains, but the two towns of Teetroon and Julalabad are now connected by a line of communication, admitting of the use of wheeled carriages during the whole of the year—these roads however unless annually repaired, will soon be destroyed, I should therefore as in the case of the Kalowala road (para. 83) recommend that an estimate should be submitted annually to the Road Fund Committee and funds be placed at the Executive Engineer's disposal for its repair.

SECTION VI.

From the Berkheri Choki to the Bynswal Choki.

139. The whole of this line is as tortuous as that described on the last section until it approaches within a mile of Bynswal, where it leaves the old course of the Shamli nulla and proceeds in a straight direction to the south. There are five bridges at the following places—Manukpoor, Khera Gudai, Kyl Shikarpoor, Tirwa, Jhinderri, and two at Bynswal constructed previously to 1830—the south bridge at Bynswal would come more naturally into Section VII.—but its introduction here will enable me to complete my remarks on the line of Canal situated between the Balpoor Falls and Shamli. The whole of these bridges being constructed on the model of the Berkheri Bridge as regards water-way, foundations, and soil upon which the works are founded, require no detailed remarks, and their position with reference to the silt deposit will be understood from Appendix B.

Manukpoor bridge and 2nd class Choki.
Khera Gudai ditto.
Kyl Shikarpoor ditto.
Tirwa ditto and 2nd class Choki.
Jhinderri ditto.
North Bynswal ditto and 1st class Choki.
South ditto, ditto.

Boonta Rajbuha.

140. Between the Berkheri and Manukpoor Bridges the Boonta Rajbuha leaves the Canal on the right bank, it extends to a distance of $9\frac{1}{3}$ miles up to the boundary of the Mulhindi estate : it is intended that this line should be connected with the projected Mulhindi Rajbuha, which is proposed to leave the Canal near Tirwa and be carried south with other feeders to the Khandla Rajbuha.

Sulawur Rajbuha.

141. The Sulawur Rajbuha which leaves the Canal on the left bank between the Kyl and Tirwa bridges, joins the Julalabad line of irrigation near the village of Heendh, after extending over a course of 3 miles.

Shamli Outlet.

142. The Canal at the distance of one mile north of the Bynswal Choki leaves the old course of the Shamli nulla, which strikes off to the south-east towards Sulawur, and passing under the walls of the town of Shamli joins the Kirsunni river near the villages of Bhulwa and Jhul. It was originally intended that this nulla should act as an escape for flood water from the Canal, and be provided with Dams for irrigation. At the point of separation, an outlet head, similar in every respect to those at the Pandhoi and Kirsunni Outlet, was built : from the circumstances before explained, however, the use of this work for an escape was negatived, not only by want of slope in the early part of the course of the nulla, but from this want of slope choking the escape channel with silt. The early and rapid filling in of the Canal channel itself, with deposits also, has rendered this work useless, excepting for the purposes of irrigation, which would be infinitely better

attained by a cut brought from the Canal near the site of the old village at Tirwa. Should the silt deposits clear themselves out, as may be in time expected—and should the water in the Canal become charged with a smaller quantity of silt—this outlet might be converted into the head of a Rajbuha to act as another feeder of the Julalabad line of irrigation.

Bynswal First Class Choki.

143. The 1st class Choki at Bynswal is similar in plan to those before described, the centre room however has a flat roof—the building is in good order—there are no workshops or buildings attached.

144. I have now arrived at the point where the main deposits of silt in the central part of the Canal terminate. My Report on the levels in 1837, *vide* Appendix A., will shew the opinions upon which I have acted, and which for the sake of explanation I will here recapitulate. I considered that the deposits which have so rapidly formed south of Suharunpoor originated in the wear and tear of the Canal bed in its northern regions, more than from the beds of the mountain torrents: that on a proper regimen of slope being established in the Canal north of Suharunpoor, by the construction of masonry falls, the introduction of silt would decrease, and perhaps cease entirely: that the slope of the Canal bed south of Suharunpoor, varying from 30 inches to 20 per mile, was too great to maintain the existing deposits, without an *influx* of silt equal to the *efflux* arising from this declivity of bed, and I consequently argued that when the masonry falls were completed, we should gradually get rid of the deposits up to a certain point, which is shown by a dotted line drawn on the longitudinal section which accompanies Appendix A,—and which dotted line was the surface of an uniform slope drawn from the tail of one fall to the sill or wasteboard of that in advance. The truth of this theory

was plainly shewn immediately after the construction of the Belka, Ghoonna, Nugla, and Bobyl Falls, in the total removal of the deposits which had established themselves in great force at Manukmow and its neighbourhood, the bridge floorings at Manukmow having at one time had upwards of 3 feet deposit.

145. Since that period the falls have been entirely completed to a post 8 miles south of Manukmow, *i. e.* to the Balpoor Falls; north of which there are now no deposits of any description. Previously to the establishment of these latter falls, the Myhee, Nowrungpoor and Rampoor Bridges had heavy deposits upon their floorings; in 1843 as will be observed by the section in Appendix B., those at Myhee were completely cleared away, and at Nowrungpoor, and Rampoor, the height of high-water was greatly decreased, shewing that the silt was moving forward—the present high-water at Nowrungpoor is 18 inches lower than it was formerly, with a much greater supply of water in the Canal.

146. This clearing out or forward movement of the deposits, must under any consideration be gradual, it is impeded however greatly by two causes—1st, the tortuous course of the Canal channel from Rampoor to Bynswal; 2ndly, the interruption given by the numerous bridges, the water-ways of which were originally contracted but which have become more so, in consequence of their present state, arising from the deposits.

147. In 1833 the archways of the bridges above alluded to became so choked with water, that it was thought advisable to prohibit the passage of rafts down the canal, an arrangement which was much against both the interests of the works, and the wishes of the community. In 1836 after estimating the probable annual return for the rafting of timber, and the probable injury caused to the bridges, with the cost of re-building or re-constructing any works of this sort which might be injured by cancelling the order of 1833, taking into consideration moreover the evident

desire of timber merchants and others to use the Canal for rafts, the said order was cancelled.

148. My calculations tended to the belief if not certainty, that the transit duties per annum would average 500 Rupees, or in every three years a fund would be supplied equal to the construction of two new bridges. The results, as will be seen in Appendix E., were as follows :—

	Rs.	As.	P.
1836-37	88	12	4¼
37-38	262	3	0
38-39	426	8	1
39-40	566	12	7
40-41	937	15	5
41-42	963	2	11
42-43	522	2	8
43-44	351	5	11
Total up to April 30, 1844,	4118	14	11¼,

or averaging 514 Rupees 13 Annas and 10 pie per annum, equal to the probable reconstruction of five new bridges.

149. It is surprising when taking into consideration the state of high-water upon the bridges, *vide* Appendix B., how rafts could ever have been forced through them; such however was the case, although with much wear and tear to the masonry of the arches—latterly however, whether from the markets on the line of the Canal being overstocked, or from the inconveniences of passage, there has been a falling off in the transit duties.

150. The levels of the Canal bed, as shewn in the longitudinal section attached to Appendix A., *vide* the dotted line, would in all probability be the actual bed which the Canal would form, were its course in a straight line; thus however, not being the case, and as every deflection from the direct line acts as a Dam and Fall, in a greater or less degree; the true level which the Canal

will ultimately take up, may be somewhat modified; at any rate, until the effect of the stream upon the deposits is clearly exhibited, it would be unwise to commence the re-construction of bridges; it being however most desirable both for the free passage of the stream, and for that of rafts, that some improvement should be made, I recommend that the following operations be immediately undertaken.

151. The arches both of the centre and *side openings* to be removed from the following bridges:—

1.	Kullurpoor.	7.	Manukpoor.
2.	Abba.	8.	Kehra Gudai.
3.	Mynpoor.	9.	Kyl Shikarpoor.
4.	Bahaumajra.	10.	Tirwa.
5.	Poonjna.	11.	Jhunderi.
5.	Berkheri.	12. & 13.	N. and S. Bynswal Bridge.

It is particularly desirable to remove the arches from the side as well as centre openings to give an increased and less impeded water-way. The piers are then to be raised, and a wooden platform resting on timbers to be contructed upon them, it will be advisable perhaps to raise the piers to such a height that the under part of the timber should not be less than 3 or 4 feet above high-water mark.

152. The total cost of this alteration would be about 3,900 Rupees—allowing at a rate of 300 Rupees per bridge—I should recommend that the timbers be neither squared nor cut, but that the whole of the wooden superstructure should be roughly, although strongly fixed, so that when the time for permanently reconstructing the bridges arrived, the timber might be beneficially disposed of elsewhere.

153. In re-constructing these masonry bridges, I should remove the side openings altogether, and design the new work in one span as at Bursa with a towing path; south of Berkheri, this

span might be reduced to 28 feet. Counter-arches and curtains are to be recommended.

154. The alterations above proposed, would throw the whole of the line from the head to Bynswal open for rafts, which in the present state of things is sufficient for all the navigable wants of the Canal.

155. The raising of embankments on the whole line from the Nowrungpoor Bridge to the point where the Shamli Nulla leaves the Canal, has been very extensive, especially north of Abba, and between Tirwa and the Shamli Outlet, this work has been carried on in the face of very great difficulties, and I am bound to pay a compliment to the memory of an overseer now dead, Mr. Sub-Conductor Petrie, for the indefatigable zeal and labour shewn by him in maintaining the banks, and keeping up the Canal supply at a time when the silt deposits were forming so rapidly, and on such extended lines, that it was only by the greatest industry that the matter could be kept in its proper channel. These embankments may now be said to be completed; for the last two years no breaches have occurred, and I am satisfied that the sums of money, large as they are, which have from first to last been expended upon them, will be a source of regret to none of my successors.

SECTION VII.

From the Bynswal Choki to the Kandla Choki.

156. I have in my last section described the south Bynswal Fridge which is situated about a mile from the Choki. Immediately north of this bridge, and on the east bank, the Gorhni Rajbuha leaves the Canal—this water-course extends to a distance of four miles passing the

Gorhni Rajbuha.

Shamli Nulla by a aqueduct, and terminating on high land on the left bank of the nulla; it delivers water for irrigation on the Shamli and Bunnut Estates with every advantage to the cultivators. It was built at the expense of Government, on estimates sanctioned previously to 1830, for the construction of Dams on the line of the Shamli Nulla. The aqueduct is a sound and well constructed building, the water channel has a capacity in transverse section of 10 superficial feet, the width of the top 3, bottom 2 and the depth 4 feet: the bed of this channel is elevated above that of the nulla, 10 feet—since the work was finished the bed of the nulla has silted up about 2 feet—the water-way however is ample, being 16 feet, divided into two openings of 8 feet each. The Rajbuha terminates at a bridge built over the high road between Suharunpoor and Shamli; there is a 2nd class Choki at this point, the internal dimensions of which are 14 × 10 feet. Between the terminus of this line and the Kirsunni River at Bunnut, the fall is very great,* and ample means are offered for establishing Corn Mills or other machinery should the loss of water be hereafter a matter of no importance. These works were constructed by Lieutenant Napier in 1833-34, at an expense of Rs. 2,079-12-2.

Mundiat, Shamli Meerut, Shamli Kyrana, and Lalooen Bridges.

157. On referring to the longitudinal section of the Canal levels, it will be observed that opposite Shamli the declivity of bed as originally projected was exceedingly small, with a rapid fall in advance towards Khundraoli. In the plan which was proposed by me in 1837 for the correction of the slopes, and reducing them to some degree of uniformity, It was determined that all the line opposite Shamli should be lowered (and the bar of earth removed)

* From the flooring of the Gorhni Aqueduct to the bed of the Kirsunni river under Bunnut, a distance of 2½ miles, the fall is 27½ feet.

as shewn by the dotted line—the immediate removal of this bar appeared to be of importance, as it would give the deposits which had established themselves *above*, an inclination to move *forward*—the clearing away of the bar however was impossible, without shutting the Canal for a period, which would have interfered with irrigation, it was a matter of no difficulty however to re-construct the bridges and lower their floorings to the proper level, after which opportunities might be taken of clearing out the bed of the Canal at times when the Canal was closed. During the year 1837-38—the four old bridges at Mundait, Shamli north, and Shamli south, with that at Lalooen, were removed, and new works built, with single spans of 25 feet, with counter-arches and curtains as before. These works are I believe in good order, they were built by Sergeant Petrie, but the same defect as that before explained which appears at the Myhee and Bursa bridges, arose in the removal of the centerings at the Shamli south Bridge, where the settlement to the crown has led to an unseemly flattening to the curve.

158. The Shamli Mills, situated at the head of a ravine close by the town of Shamli, are supplied from two outlets from the Canal, one near and south of the Mundait, and the other north and close to the Shamli north Bridge. The Mills which are adapted to two sets of stones for grinding corn, are at a distance of one mile from the Canal. The object in having two heads, is to admit of the silt being cleared from one whilst the other is in use, and by these means keeping a constant supply of water upon the Mills: the tail water escapes into the Shamli Nulla. The silt deposits formed by this tail water have been great, they have completely warped up a large tank through which the cut was conducted, but they have lately diminished in extent, and by an occasional clearance will be easily corrected—the Mill channels at the points where they leave the Canal are also much incommoded by silt,

Shamli Mills.

especially at the lower one, where the mountains of sand already collected are enormous. I have tried in vain to make the working parties throw the sand (when excavated) in rear of the banks, so as to form an esplanade, and get rid of the untidy appearance caused by irregular heaps—the evil however is not in the appearance alone; as in the case above alluded to, the passage along the cut is prevented by the heaps of sand, which in some places have been piled up in the plantations until the stems of the trees are buried. There are two small masonry bridges on the lower Mill supply channel that require repair—with this exception the buildings are perfect, they were constructed under the immediate eye of Lieutenant Robert Napier, of the Engineers, in 1831-32, at a cost of Rs. 2,398-14-3, and are in my opinion amongst the best of the Canal works.

Kheeri Outlet.

159. South of and close to the Shamli south Bridge, on the east bank is the Kheeri Outlet or escape—a most efficient work for the purposes required; it consists of two openings of 6 feet wide each, with overfalls and an inclined plane to the bed of a cut connected with the Shamli Nulla. I regret that in the design for this work a larger water-way had not been given, should such an improvement ever be contemplated I would recommend two additional openings similar in size to those already built—an arrangement which would admit of the Canal south being laid dry with much greater rapidity than at present. The difference of level between the Canal bed and that of the Shamli Nulla, which is close by, is upwards of 14 feet; the nulla has a deep, spacious and well defined section, increasing in size as it approaches the Kirsunni river, and is capable of holding any quantity of water that may be thrown into it by the Canal, without that interference from silt deposits which has ruined the escapes at the Pandhoi,

Kirsunni and Shamli Heads, which were originally projected. I may here refer to my first Report on the Ganges Canal, paras. 84 to 89, on the subject of escapes, and the evils to be apprehended from establishing them at points where the declivity of the bed of the nulla into which the water is thrown is either small or less than that of the Canal channel. The Kheeri Escape is situated at the head of the southern division of the Canal works, and provides a perfect control over the supply to the Overseer of the Division. From the difference of level between the Canal and Escape side of this work, the water has a natural tendency to get under the foundations—these ought therefore to be carefully watched and protected both in front and rear—as the soil however is good, every security for stability is naturally offered—the interior slopes of the Canal however, both above and below the bridge, as connected with the outlet, ought to be piled, as the action of the current when the escape is in full use, upon the slopes and sides of the Canal is very severe. This work was built by Mr. Sub-Conductor Brew.

Kheeri Choki, Second Class.

160. There is a second class Choki at these works similar to that at Rundole, a circular room 20 feet in diameter, thatched—this room has been divided by me into two semi-circular apartments, so that accommodation may be provided for an European Officer; the establishment of an escape at this post, having raised it to one of importance.

North Khundraoli Bridge.

161. The north Khundraoli Bridge was built in 1835 at a cost of Rs. 835-10-8, it consists of a span of 23 feet, three of which is occupied by a towing path. The water at the present time stands high upon the arch, but not sufficiently so as to in-

terfere with navigation—the work is in good order, and requires no remark.

South Khundraoli Bridge.

162. The south Khundraoli Bridge was built previously to 1830—it consists of one arch of 18 feet span. The masonry of the arch has been injured by rafts, but in other respects the bridge is, I believe, in good order. The water-way however is contracted, and the height at which the water now stands is an impediment to rafts. As this bridge and another at Romalla (hereafter to be described) are the only ones which interfere with the passage of boats from the tail of the Canal at Selimpoor to Shamli, I should recommend its re-construction on a plan similar to that of the northern Khundraoli Bridge—but with the intrados of the arch more elevated.

Khundraoli Choki, Second Class.

163. Near the bridge last described is a second class Choki in every way similar to that at Rundole.

Punjokri Bridge.

164. The Punjokri Bridge is similar to that described in para. 162, but with a narrower roadway—it was built previously to 1830, and is in good order.

Kandla Bridge and First Class Choki.

165. The Kandla Bridge is exactly the same as that described in para. 162—it was built previously to 1830, and requires no remark—the first class Choki is similar to those before mentioned,

but with a flat roof to the centre room, this building is in good repair.

Embankments.

166. There has been a good deal of bank raising, between Bynswal and Kandla. From the former place to a point north of the Mundait Bridge, the embankments have been much raised and strengthened, the soil at some places however is impregnated with an alkali (which will neither admit of its binding, nor of the growth of vegetation upon it,) and is not to be depended upon. From Khundraoli to the Punjokri Bridge also there has been heavy embankment work, especially south of Khundraoli, and opposite the village of Futtipoor—at this time however these banks are in good order and fully capable of maintaining the Canal supply.

Kandla Rajbuha.

167. About half a mile north of the Punjokri Bridge and on the west bank, the Kandla Rajbuha leaves the Canal, this line after continuing its course for five miles divides itself into two branches, the one towards Loonb through which Estate it is carried towards Heewa, Meerpoor, &c., and the other towards the northern boundary of the Kirthul Estate.

Bubeesa Rajbuha.

168. The head of the Bubeesa Rajbuha leaves the Canal on the east bank, immediately north of the Kandla Choki—it continues for $3\frac{1}{2}$ miles to the boundary of the Khunyan lands. The shareholders of the Kandla Rajbuha ought to be made to build a second class Choki on the general Canal plan at the head of their line—the mud building at present existing is a deformity; this remark applies to other Rajbuhas also south of Kandla, and will be referred to in the chapter on Rajbuha irrigation.

SECTION VIII.

Kandla Choki to the Barote Choki.

169. With the exception of the north Baoli Bridge the whole of the bridges on this section as noted, in the margin, were built previously to 1830—they are on the same model as that at Kandla, with a span of 18 feet, counter-arched, and with curtain foundations—they are in good order and require no remark, further than that the Romalla Bridge requires to have its arch removed, and superstructure heightened to admit of the passage of rafts; I should recommend that this be done immediately, and at the same time as that referred to at Khundraoli in para. 162: the Canal will then be available for boats and rafts on the whole line from Shamli downwards. The plan which I should adopt in restoring the bridge would be similar to that which was formerly practised at the Lawalpoor Bridge, viz. to remove the arch, and build one new pier in rear of one of the old ones, leaving the old one as a towing path—this would give a span to the new arch of 22 feet—the increased height to the pier would depend on the highwater mark, but the crown of the arch ought to be at least 4 feet higher—a curve drawn on a true ellipse, gives a great height to the haunches, and is therefore preferable to that described on three centres, which has always an awkward appearance. The north Baoli Bridge was built in 1832, at a cost of Rupees 864-11-9—the span is 20 feet, deducting $2\frac{1}{2}$ feet for the towing path; the style of foundations and design of elevation are the same as those before described. There are 2nd class Chokies at Kukripoor and Bural similar to that at Reeree.

Bharsi Bridge.
Nalla ditto.
Kukripoor and 2nd class Choki.
Romalla Bridge.
Bural ditto and 2nd class Choki.
Baoli north Bridge.
Ditto south ditto.
North Barote Bridge.
Central ditto.
South or Burrowli ditto.

Bunhera Rajbuha.

170. South of the Bharsi Bridge on the east bank, the Bunhera Rajbuha leaves the Canal, it joins the main line described at para. 168, after extending through a course of about $1\frac{3}{4}$ miles near Khunyan.

Kirthul Rajbuha.

171. About half way between the Nalla and the Kukripoor Bridges, the Kirthul Rajbuha leaves the west bank of the Canal, keeping to the boundary, separating the estates of the two villages; its course at present does not exceed a mile in length, but it was intended eventually to connect it with the Kandla line, and ultimately to make it a link of a chain of Rajbuhas terminating in that of Khekra.

Bujwarra Rajbuha.

172. The Bujwarra Rajbuha which extends for 26 miles running centrically between the Canal and the Hindun and the Kirsunni rivers, leaves the Canal north of the Bural Choki on the east bank. This is the main trunk of a system of irrigation, which will when completed, introduce the benefits to be derived from the Canal water to the whole tract of country to the east bounded by the Hindun river—a Choki similar to that which has been built on the Julalabad line at Bunhera, has been constructed at the head of the Bujwarra Rajbuha. This water-course was opened in January, 1842.

Bujwarra Rajbuha, Second Head.

173. A second head or feeder to the line described in the last paragraph leaves the Canal on the northern boundary of the Baoli

lands between the Bural and north Baoli Bridges, after a course of three miles, it joins the main trunk in the lands of Bujroul.

Loen Rajbuha.

174. The Loen Rajbuha leaves the Canal on the west bank, south of the south Baoli Bridge—it extends for a mile, and will ultimately form a link of the chain referred to in para. 171.

Burrowli Rajbuha.

175. The Burrowli Rajbuha leaves the Canal on the west bank immediately south, and close to the north Barote Bridge, it extends for about five miles to the boundary of Beharri and will eventually act as a feeder to the Khekra line—a 2nd class Choki is situated at the point where the Burrowli Rajbuha leaves the Canal, and a masonry outlet built previously to 1830 has been taken advantage of, as the head of supply.

Barote First Class Choki.

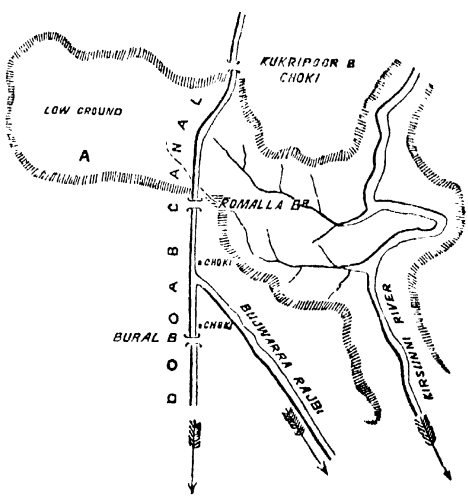
176. The Barote 1st class Choki is situated on the east bank near the centre bridge, it has a flat roof and is built on the same plan as those before described.

Embankments.

177. The raising of embankments on this section has not been extensive, and has been confined chiefly to the tract between the Kukripoor and Bural Bridges—south of Kukripoor the Canal crosses low land, the heads of ravines which drain into the Kirsunni; at this point the banks have been raised to a great height, and at some points are 10 to 12 feet above the surface of the country—the lands to the west of these high embankments have been entirely cut off from the ravines which were their natural line of drainage, and on one occasion, the falling of a tree on the west bank (which

had improperly been allowed to stand within the limits of the external slopes of the banks) over the channel of the Canal, led to a breach on the west, which flooded an enormous surface of country, and although the damage done to crops was fortunately inconsiderable, the danger to be apprehended from a recurrence of bank breaking at a spot where the country was richly cultivated, led to the design of a masonry tunnel under the Canal, for the purpose of securing an escape for water (under accidents of this sort) to the ravine heads and ultimately to the Kirsunni river.

DIAGRAM 14.



178. The above diagram will shew the position of the Canal

with the drainage towards the Kirsunni river. The low ground marked A is of considerable extent, richly cultivated, and to all appearance free from either jheel or stagnant water, the soil is, I imagine, capable of absorbing rapidly, and when water collects it passes off down the boundary ditch of the Canal, and at other points on its southern boundary—after the accidents above alluded to, however, the whole of this low ground was a sheet of water as far as the eye could reach, although fortunately it occurred in either October or November, when the ground was preparing for the cold weather crops, and only a small portion of the surface had been sown. The masonry tunnel would be established at some point north of the Romalla Bridge, where the country is high, and where during the operations the Canal could be turned into a new channel. The Kirsunni river which is at a distance of three miles runs through a deep valley, and the fall between the Canal and the bed of this valley is very great—the proximity of the ravines to the Canal moreover would reduce the expense of the excavation of the escape channel greatly—if therefore a cut was made leaving the hollow A at its deepest part and carried under the Canal towards the ravine head as shewn by the dotted line in the diagram, the hollow would be protected from inundation under any accident that might occur to the Canal embankments. Should the Kheeri Escape be hereafter considered at too great a distance from the lower regions of the Canal, another might be established near Kukripoor; the ground is favorable to such an undertaking, but it would be necessary to watch the action of the water on these ravines, and prevent them from retrograding; a circumstance which the excessive slope of country would greatly facilitate. Great pains have been bestowed on the embankments south of Kukripoor, all trees situated within the limits of the internal slopes of the banks have been removed, and I believe that with the usual repairs, and protection from vermin, they will remain sound and perfect.

SECTION IX.

From the Barote Choki to the Deola Choki.

179. The south Barote or Barrowli Bridge has been described in the last section, this is situated about a mile below the Choki; in advance are the Lowalpoor, Bichperi, Basode, and Deola Bridges—the three latter consisting of one span of 16 feet wide, with foundations as before described curtain and counter-arched—the Lowalpoor Bridge* had its arch raised 3 feet in 1837, and in making this alteration the plan described in para. 169 and recommended for the Romalla Bridge was adopted—the present Lowalpoor Bridge therefore consists of an arch of 20 feet span, including the old pier as a towing path—the work is in good order, and requires no further remarks.

Lowalpoor bridge.
Bichperi ditto and 2nd class Choki.
Basode ditto.
Deola ditto.

Bichperi Second Class Choki.

180. There is a 2nd class Choki at Bichperi, similar to that at Reeree.

Khekra Rajbuha.

181. At a short distance south of the Lowalpoor Bridge and on the west bank is the head of the Khekra Rajbuha, with a 2nd class Choki attached similar to that at Bichperi. The Ludwarri Raj-

* The distance between the south Barote and the Lowalpoor Bridge is about 4 miles, and as the intermediate estates of Pulhera and Adureespoor are divided into two portions by the Canal, I would recommend that a bridge should be built, the situation of which should be on the boundary separating the lands of Pulhera and Adureespoor.

buha also leaves the Canal at a point near this Choki. Both these lines are very effective for irrigation, the former after extending through a course of 19 miles rejoins the Canal through the Cherouri inlet, south of the Sookulpoor Bridge and falls, the latter is a short line of about 4 or 5 miles irrigating the lands of Suroorpoor and Ludwarri. At the point where these Rajbuhas leave the Canal there are other temporary water-course heads, these ought to be closed and some arrangement made for uniting them with the Ludwarri Rajbuha, and giving one masonry head for them all. The head of the Khekra line is a good masonry building, capped and grooved with stone, the silt however which has deposited itself in the Canal since the construction of this head, has given the work an appearance of having been built on too low a level—when the silt is cleared away however this will prove not to be the case. The Khekra Rajbuha was opened in November, 1837.

182. Between the Lowalpoor and the Bichperi bridges at a distance of about half way, the boundaries of four villages Kyampoor Ghuteena, Dhodera, and Sydoolanuggur unite or come very closely together; there are two or three ghats on this line which are not only a great disfigurement, but are a positive evil in leading to injury to the embankments and in filling the channel with rubbish, I therefore recommend that a new bridge be built at the point where the four village boundaries come in contact, roads be made from each estate to the bridge, and all the ghats between Lowalpoor and Bichperi be stopped. It is necessary to connect the bridge with each estate by roads, otherwise there will be difficulties made by the Zumeendars, who always endeavour to maintain bridges built on their own estates, and at a distance from high roads as private property, built for the sole and special convenience of the village.

Khekra Rajbuha, Second Feeder.

183. South of and close to the Bichperi Bridge, on the west

bank, is a second feeder to the Khekra Rajbuha, it leaves the Canal through a masonry outlet built previously to 1830, consisting of a centre arch of six and two side ones of 3 feet wide each —this outlet is similar in every respect to that at Barote described in para. 175 as converted into the head of the Burrowli Rajbuha, the feeder joins the main line in the lands of Pootbee, after extending through a course of $2\frac{1}{2}$ miles.

184. Near the village of Chopra, about half way between the Bichperi and Basode Bridges, the Husaoda Rajbuha leaves the east bank of the Canal, this is intended as a feeder to the Bujwarra line, and is in length about 5 miles.

Deola Rajbuha.

185. Immediately north of the Deola Choki, on the east bank, the Deola Rajbuha leaves the Canal, this is another feeder to the Bujwarra line, and is three miles in length.

Embankments.

186. The banks in the neighbourhood of Lowalpoor, as well as north of the Deola Choki, have been raised considerably since 1830, and as the silt deposits are constantly changing their position, the high-water mark is somewhat uncertain on the greater part of the whole line, the embankments nevertheless are in capital order, and during late years have merely required occasional repairs.

Deola First Class Choki and Mango Graft Plantations.

187. The Deola 1st class Choki is similar to that at Barote with a flat roof, and attached to it is a mango graft plantation of, five acres.

SECTION X.

From the Deola Choki to the Surrowli Choki, Khutta Bridge and Second Class Choki.

188. The Khutta Bridge, which is situated three miles south of the Deola Choki, is built on the same model as that at Deola but with the roadway of 12 instead of 15 feet, it has one arch of 16 feet span—the 2nd class Choki is the same as that at Bichperi.

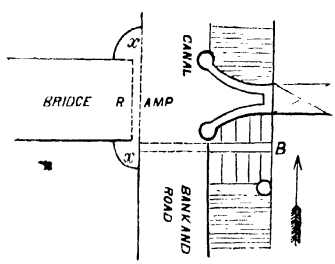
Dhukowli Rajbuha.

189. North of this bridge and on the east bank, the Dhukowli Rajbuha leaves the Canal and acts as another feeder to the Bujwarra line of irrigation—the length of the Dhukowli Rajbuha is two miles.

Muhrumpoor Bridge.

190. The Muhrumpoor Bridge has one span of 20 feet in width including a towing path of $2\frac{1}{2}$ feet—on its upper face there are ghats 20 feet in length attached to the bridge on both sides of the Canal, the ghats are pierced with channels connected with reservoirs, situated in rear of the embankments, both above and below the bridge ramps, as shewn in the following plan :—

DIAGRAM 15.



x x being the reservoirs supplied from the outlet B by under-channels as dotted in the diagram. The advantages proposed by this arrangement, were to give water for irrigation on both sides of the road without interfering with the roadway, and at the same time to retain all benefits arising from afflux, to the supply of the reservoirs, the arrangement was moreover compact, and the outlets under control. The plan does not however appear to be approved of, the channels get choked with silt and the slopes of country don't admit of a free flow to the water in the water-courses. I have no doubt, that were a Rajbuha or line of irrigation carried out on proper levels from the reservoirs situated on the south of the bridge ramps, the evils complained of would cease. This work was built in 1832 at a cost of 764 Rupees.

Burragaon Bridge.

191. The Burragaon Bridge is similar in every respect to that at Khutta.

Mobarukpoor Bridge.

192. The Mobarukpoor Bridge was built at the same time as that at Muhrumpoor, and on the same model, the same remarks apply to it in every way.

Rutoul Bridge.

193. The Rutoul Bridge has one arch of 15 feet span, and its style of construction is similar to those built previously to 1830— attached to this bridge is a 2nd class Choki, similar to that at Khutta.

Surrowli Rajbuha.

194. North and close to the Rutoul Bridge, the Surrowli

Rajbuha leaves the Canal on the west bank—this Rajbuha is four and a quarter miles in length, and falls into the Canal above the Sookulpoor Falls.

Surrowli Bridge, First Class Choki, Workshops, and Mango Graft Plantations.

195. The Surrowli Bridge is similar to that at Rutoul, and the 1st class Choki the same as before described, with a flat roof. Attached to this Choki is a yard with carpenters' and smiths' shops, and a mango graft plantation, occupying about 5 acres—a masonry well was completed for the use of the yard and establishment in 1844.

Kotwalpoor Rajbuha.

196. The Kotwalpoor Rajbuha leaves the Canal on the east bank at the Surrowli Bridge, by a masonry outlet pierced through the north wing wall, and passing obliquely through the ramp; this arrangement gives the water-course the advantage of high levels, and is in every way compact, as well as effective. The Kotwalpoor Rajbuha keeps its course over the high lands to the east of the Canal for 7 miles until it reaches Mundowli, a village on the edge of the Khadir, at this point the water escapes down the high bank and passes off to the Jumna.

Embankments.

197. The embankments between Deola and Surrowli have undergone much alteration since the Canal was opened; in the neighbourhood of Khutta they have been raised, but to no great extent, and at the present time the whole line is in good order.

SECTION XI.

From the Surrowli Choki to the Selimpoor Choki and the Jumna River.

198. About 2 miles south of Surrowli the descent into the Khadir or low lands of the Jumna, is gained by three descents or falls, which were built in 1833-34 by Serjeant and Overseer Brew. At the village of Sookulpoor, a bridge with one arch of 15 feet span was built previously to 1830—to this arch an additional one of the same span was added, the front foundations of the old work were protected by a curtain wall, sunk in front to a depth of 10 feet—and falls and chambers were constructed to the rear. The work now consists of two spans of 15 feet wide each, with side passages of communication along the berm. The eastern chamber is locked, and the tail well protected by piling and blocks of the quartzose sandstone from Delhi—attached is a Choki similar to that at Rutoul. This work is in good order, and requires no remark.

Sookulpoor Falls and Lock.

Sikrani Falls and Lock.

199. The Sikrani Falls and Lock are similar to those at Sookulpoor, there was no bridge at this spot originally, the work therefore is entirely new. Both here and at Sookulpoor the descent or difference of level between the sill and flooring of chamber is 8 feet. A Choki corresponding to that at Sookulpoor is attached to this work.

Jaoli Falls and Lock.

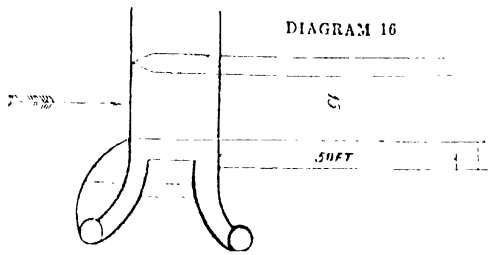
200. The Jaoli Falls and Lock have only a descent of 7½ feet. Here, as at Sookulpoor, a bridge of one span of 15 feet was built previously to 1830—the alterations made were similar to those as

described at Sookulpoor—a 2nd class Choki is attached to this post also.

201. These three works are, I consider, amongst the best on the Canal—at Sookulpoor the foundations rest on good soil, but at Sikrani and Jaoli this is not the case, they are however sunk to a considerable depth, the tail curtain wall being 12 feet and the revetments being 4 feet deep, the flooring of the chambers are counter-arched, and the style of building altogether massive.

202. On the revetments to the west, an inlet and outlet have been arranged for mills, should such be hereafter required, the holes are now blocked up, but the masonry can be removed. The inlet channel is constructed in rear of the abutment of the bridge, and the outlet will be found at a distance of 50 feet from the rear face of the bridge.

DIAGRAM 16



Cherouri Inlet.

203. On the west bank, south of, and near the Sookulpoor Falls, is the Cherouri Inlet, which I have in the 181 para. described as the tail of the Khekra Rajbuha. This inlet with a width of water-way of 6 feet, was built previously to 1830, it was necessary therefore when the falls were made at the bridge, to lower the flooring of the inlet, the depression required was 5 feet; Mr. Brew made the required alteration by under-building, without removing the superstructure, a work that was most successfully performed

in 1833. There is a heavy rush of water into the Canal through this inlet during the rains, and frequently much cutting away of the opposite bank—this has been protected by piling, but it requires to be carefully watched and looked after.

Jaoli Escape.

204. Immediately north of the Jaoli Bridge on the west bank, is an outlet to the Ranup Tank; the line has merely been excavated and cleared out, and no masonry escape has been made; I have preferred leaving an opening in the bank to admit of a free escape, as the floods during the rains, arising in a great measure from the inlet, at Cherouri are very severe, and, coming down in force upon the falls, might do injury.

Ranup and its Tulao.

205. The escape towards Ranup was in all probability the original course of a cut from the Canal, to fill the lake at that place. This lake or tulao has been formed, by building a massive revetment fitted with sluices across the bed of a valley, so as to regulate the height of the water. The revetment is built of large square blocks of the Delhi rock, with ghats or steps at intervals. It extends for perhaps half a mile, offering a concave outline towards the water—numerous buildings and the remains of a palace are attached, and the revetment backed, as it is by an esplanade of earth, with groups of large mango trees scattered about in its neighbourhood, is a very striking object. A good deal of this noble work is in very tolerable repair, but portions of it have fallen down, and the stone has been removed for other purposes.

Gokulpoor Bridge and Escape.

206. South of Jaoli is the Gokulpoor Bridge and Escape; this work was built previously to 1830, but was altered in 1836 by

raising the arches and piers to a height of 3 feet—it consists of two arches of 15 feet each, with foundations protected by curtains and counter-arches. The east arch carries the Canal in a straight line towards the Jumna—the west arch is the escape into the Geounda Nulla—these two lines are separated on the southern face of the bridge, by a wall, 40 feet in length—the escape is regulated by sleepers.

207. The distance between the Jaoli Falls and the Gokulpoor Bridge is four miles, and the want of a bridge in the intermediate distance is much felt—this would be best constructed near the village of Behta, at which place there is a ghat, that is a constant source of trouble and expense.

Gokulpoor Second Class Choki.

208. There is a second class Choki at the Gokulpoor Bridge, similar to that at the falls above.

Selimpoor Bridge.

209. From the Gokulpoor Bridge to that at Selimpoor, the Canal has been excavated on a perfectly straight line for 16,828 feet. The bridge at Selimpoor was built previously to 1830, and has one span of 15 feet with its foundations, protected by curtains and counter-arches—as this is the crossing for the high road between Meerut, Aligurh and Delhi, the roadway was made 18 feet wide instead of 15, as was the case in all other instances where main lines were crossed.

Road between Meerut, Aligurh and Delhi.

There are mills for grinding corn attached to the southern face of the Selimpoor Bridge, and connected with it by a line of masonry ghat, on a width sufficient to admit of two more mills should such be called hereafter, these mills terminate in a chamber with revetments similar to those

Selimpoor Mills.

at the falls above described. The mill houses are situated on the right and left of the Canal channel, each house containing two sets of stones; at the rear of each house are store-rooms. The Mill Dam is formed by throwing sleepers over the main channel immediately south of the mill shoots, and at the head of a descent (constructed in the form of a series of steps) of 64 inches, which delivers the water on a level with that of a branch connected with the Jumna River. The foundations of the whole of these buildings although in sand, are massive; and the tail walls are sunk to a depth of 8 or 10 feet, protected in front by large masses of Delhi rock—they were built by Serjeant Brew in 1832, at a cost of Rs. 4,792-15-0, since which period they have required little repair, and at this time are in capital order. The buildings are flat roofed with masonry terrace, and the greater part of both the houses and the Canal channel is built of the small native brick with lime cement. Additional mills might be constructed at this place with great advantage to the Canal revenue.

Selimpoor Choki 1st class.

North of the bridge is a Choki 1st class. At the time when the mills were under construction, this Choki which was a single circular room of 20 feet diameter, was enlarged by the addition of a verandah, including store and Chokidar's rooms; an improvement which the increased importance of the post rendered necessary. Firewood, &c., brought down the Canal was here stacked and put up for sale, and the constant attention of an European, rendered accommodation for him and the establishment necessary. A mango graft plantation, similar in size to those before mentioned, is situated to the north of this Choki on the east bank.

Selimpoor mango graft plantation.

Embankments between the Surrowli and the Selimpoor Chokies.

210. The embankments from Surrowli to the Jaoli Falls have not been raised, but the construction of the Sookulpoor and Sik-

rani works, and the deepening of the bed of the Canal channel has led to their being much improved and widened out. From Jaoli to Selimpoor, however, the raising of embankments has been extensive, especially in the neighbourhood of the Behta Jheel, and on the line opposite that village—this has arisen in a great measure from the arrangement of the Mill Dam at Selimpoor, which by throwing a back water and maintaining the surface on a high level, has led to an extensive deposit of silt on the whole line, even *into* the lower chamber of the Jaoli lock, the fall of water into which is now barely visible. The sleeper planks at the Selimpoor Mills retain the water to a height of 5 feet above the masonry flooring of the Canal channel, the effect therefore on a stream of water loaded with silt as that of the Doab Canal is, may be easily imagined—it is singular, however, that the scour arising from the removal of these sleepers when the mills are not at work, is so slow in its action, that for weeks after the channel has been thrown open, it does not appear to influence the deposit situated opposite Behta. The Gokulpoor Escape when not in use is closed in the same way as the Selimpoor Mill Dam, that is to say, by sleepers; the upper front of this escape has, after the mills have been running for any length of time, a deposit of at least 5 feet of silt upon it! The consequence therefore of opening the escape is to throw an enormous quantity of sand, down the channel towards Geounda, and as the declivity in the bed of the nulla is small, the deposits arising from the sand, lead to inundations and to all the evils arising from the passage getting choked up. It is usual therefore during floods to remove the sleepers at Selimpoor in preference to those at Gokulpoor, easing off the water at the latter by the removal of upper sleepers only. This escape is one of great value to the works, as it admits of the Canal water being turned away from the Mill channel, when repairs or clearance of silt are necessary.

211. During the height of the rains, and when the Jumna river

is at its maximum, not only is the chamber of the mills filled, but the back water extends up the Canal channel admitting the passage of boats from the Jumna—this back water fills the chamber of the mill with silt, and to protect the escape channels from the mills, which enter the main chamber at its southern extremity, sluice shutters are arranged, by the closing of which the admission of silt is prevented. The buildings at Selimpoor are very prettily wooded, and great attention has been given to the neatness and tidiness of the grounds in their neighbourhood.

On the Completion of the Canal Levels from the Balpoor Falls to Selimpoor.

212. A description of the slopes of the Doab Canal, with my views on the subject, as well as the uses that may be derived from turning the Canal to the purposes of navigation, will be found in Appendix A.—I shall therefore merely state, that it has not been deemed necessary, up to the present time, to regulate the slope of the Canal bed, from the Boodhi Jumna Dam to the head of the Belka Falls—the heavy declivity on that line occurring at points where the bed is protected by boulders and shingle, whilst the passage of the rafts (which only move downwards) is not interfered with by moderate rapids. Should the rapids, however, retrograde to such an extent as to render the construction of falls necessary—or should it appear advisable to regulate the slope, and to give lockage to the Canal from the Boodhi Jumna to the head of the Belka Falls—the following works would be necessary:—(allowing a slope of 5 feet per mile from the Boodhi Jumna to the Raipoor Bridge, and 24 inches per mile from the Raipoor Bridge to the head of the Belka Falls,) two descents of masonry of 6 feet each between the Boodhi Jumna and the Raipoor Bridge, and two of 8 feet between the latter and the head of the Belka Falls—the whole of this line however ought to be carefully re-levelled, and the falls and slope projected upon paper before any works are com-

menced upon. At present, however, there appears to be no necessity for works of this description.

213. From the head of the Belka Falls to the lower floorings of those at Balpoor, the Canal slope has been regulated as before described, (*vide* paras. 84 and 119) and the establishment of further work of this description in advance depends entirely upon the clearing out of the silt deposits. It must be understood, however, that the work which has been done, consists merely in placing the sills of the falls on a proper level one with each other, the Canal bed intermediately being left either to silt up, or wear itself away as the state of the level may happen to be. The clearance out of the channel by excavation could not possibly take place without either stopping the Canal for a period, or turning its course, arrangements that were not feasible—it will be found however that wherever silting up or raising of bed was required, this has naturally taken place; and where a bar of earth intervenes, a heavy wear upon it is rapidly tending to its removal.

214. In laying down the level of the falls south of Hulalpoor, it was found desirable in practice to modify the slope proposed in the plan submitted by me in 1837—this modification led to the sill of the Balpoor Falls being raised 21 inches above the flooring of the old bridge, instead of meeting it on the same level, the figures therefore appended to the bridges for elevation or depression of flooring as shown in the sheet of level,* require modification also. In re-constructing or altering any of the intermediate bridges, it will be necessary to take the level between the sills of the two falls between which the bridge is situated, and then fix the flooring of the bridge to be reconstructed on a level proportionate to the whole fall and the distance at which the bridge is

* Reference is made to the depression and elevation of floorings as represented on the sheets of levels, these figures having undergone an entire modification have been omitted in the lithographed sheets attached to this report.

intermediately situated. I should recommend however in all cases of this sort, that the flooring should be laid 6 inches lower than the truly calculated level.

215. In advance of the Balpoor Falls, the course of the Canal is so tortuous, that it is impossible to say how far the natural slope of the Canal bed will be thereby ultimately affected—it will be seen by my section, that presuming that the course was straight, and that a certain slope was given between Balpoor and Kandla, four falls of 4 feet each would be required, viz.

One at Rampoor.
One at Kullurpoor.
One at Poojna.
One at Kheera Gudhai.

It was originally proposed, that the slope of the Canal bed from Balpoor to Poojna should be 24, and from Poojna to Kheera Gudhai 22 inches per mile. For the same reason that led me to modify the slopes north of Balpoor, viz. the disinclination to interfere with water-course heads, I should recommend a similar arrangement south, and would continue the slope from Balpoor to Kheera Gudhai at 23 inches per mile. It appears to me doubtful from the effect that the twists in the Canal have upon the bed, whether the falls at either Poojna or Kheera Gudhai will be necessary, but the Rampoor and Kullurpoor ones may, I think, be looked forward to within the next few years, and it would be advisable at both these points to collect bricks immediately. I am led to make this remark, from the very sensible removal of silt from the bridges south of the Balpoor Falls. Should the silt clear out from the Canal bed, in spite of the tortuosity of its course, between the tail of the Rampoor Falls and Kandla, on the uniform slope shown in my section, three bridges only would require raising, viz. those at Nynpoor, Tirwa and Jhinderri, and the establishment of falls at the four places above specified, would render the whole line complete ; with reference, however, to the 147th paragraph, and the

demand for raft transit that is immediately required, and considering the annual returns from such transit, there can be no doubt of the desirability of making alterations to all the bridges from Kullurpoor to Bynswal as described in para. 151.

216. Every opportunity should be taken when the Canal is dry, of getting rid of the bar of soil opposite Shamli, and between the Mundait and Lalooen Bridges—this will be best done, by commencing at the tail and working backwards, the removal of this elevated portion of the Canal bed, would tend greatly to the progression of the deposits north of Bynswal. The floorings of the bridges above alluded to have been already lowered, as explained in para. 157.

217. In Appendix A, I have given my reasons for not proposing alterations to the Canal slopes south of Kandla, or from the Kandla Bridge to the head of the Sookulpoor Falls—a reference to the longitudinal section where the thin black line shows the present Canal bed, and the dotted one that of an uniform slope of 20 inches per mile, will shew distinctly not only that any alteration of the sort would completely interfere with the irrigation, but that with the small quantity of water with which we have to deal in this tract, the level of the thin black line of the original project, is perhaps the most advantageous one for the purposes of irrigation, for which alone this Canal was designed. The embankments have already been made to meet the silt deposits and consequent rise of the surface of the water in the neighbourhood of Kukripoor, Romalla and Barote, the same has been done in the Lawalpoor direction—and there appears to be no necessity whatever for depressing the floorings of the bridges between Bichperi and the head of the Sookulpoor Falls, or of deepening that line by excavation, which would not only be most expensive, and difficult, but ruinous to the irrigation of the lands in its proximity. I therefore propose, that the deposits on the Romalla and Lowalpoor districts should be met by increasing the height of embankments, should

such be required, in preference to getting rid of them by cutting through the bar extending from Bichperi to the Sookulpoor Falls' head.

218. With the alteration to the bridges from Kullurpoor to Mundait, as well as that to the south of Khundraoli and Romalla Bridges before described (*vide* paras. 162 and 169,) the Canal will be opened for boats and rafts, for the former from Gundewur, and the latter from the Jumna to Selimpoor.

219. Lock gates have been fixed in all the falls, and will shortly, I have no doubt, come into use. Rafts which, up to the present time, have been shipped at Manukmow under all the expenses of land carriage from the forests, will, it is to be hoped, be floated down from the Rajghat Mundi in the Deyrah Doon. It is extraordinary to observe the quantity of wood that even without the advantage of lockage, has been introduced into the central regions of the Canal, almost every main post has its Timber Yard, the variety however is chiefly a small rafter denominated "*Kurri*," which is used largely in building.

220. Five boats have been built for the Canal, the uses of which (in consequence of the silting up of the Romalla Bridge) have been confined lately to the southern districts—their size is 40 feet in length and 8 feet wide, they draw 24 to 30 inches of water: they were formerly employed in bringing grain from Shamli to Selimpoor, but have latterly been used for the collection of fuel for brick kilns, carriage of firewood, &c.

221. The transit duties are shewn in Appendix.

222. In conclusion, I may remark that the main deposits of silt have established themselves, precisely at those points in the section, which the theory of uniformity of slope would have demanded.

Embankments, Roads, Bunds, &c.

223. In the original excavation of the Doab Canal the embankments were formed on a scale giving terreplein or width at the

top of 16 feet. They were made from the earth taken out of the excavated channel, and where that was not sufficient, external trenches were dug to any extent required, but never exceeding 12 inches in depth, and the edges of these trenches were sloped off to enable the cultivators to plough over them. From the Canal Head to Suharunpoor the depth of section, or that from the top of the embankment to the bed of the Canal, was fixed as a minimum at 7 feet. From Suharunpoor downwards this depth was reduced to 6 feet. The excavation was carried on both by daily labourers and contractors, the contract including both the excavation of the Canal channel, and the formation of the banks. The contract rate per 1000 cubic feet was Rs. 1-4-0 from the head to Suharunpoor, and Rs. 1-8-0 from Suharunpoor to the tail of the Canal. Had there been proper European aid in superintending these embankments, and seeing that the contractors acted up to their agreement in consolidating the earth properly, these rates would undoubtedly have covered the expense of excavation, but a single Overseer could not possibly give proper supervision to a length of work of 50 miles, nor could he check irregularity amongst numerous contractors with one object only in view, which was to deceive him; the consequence was that in many places the banks had to be re-made, and in others the action of the annual rains on artificial embankments composed of lumps and clods of earth, which had been carelessly thrown in by the contractors, led to very heavy expense, and raised the average cost per 1000 cubic feet considerably.

224. Since the opening of the Canal in 1830, all these embankments have been much improved, and on the line between Nowrungpoor and Bynswal, especially, they have been much raised—the whole are at the present time in capital order.

225. To maintain a Canal in an efficient state, an open line of road along its bank is necessary, this is a rule not appertaining to the main channel only, but to every branch or Rajbuha attached; without a line of communication the works never *will be* looked after,

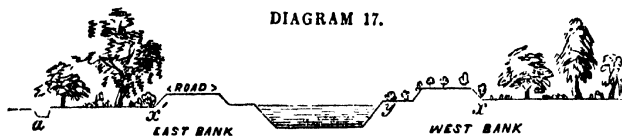
and never *can be* watched, and without those necessary ingredients for supervision, matters will not only go wrong in water-course heads and works of that sort, but very serious accidents may happen to the embankments, without the means of repair being available. Where a good road exists, means are offered for a daily patrole along the Canal, for a careful inspection of the whole line of works by the European officers and others; accident occurring is immediately reported, material is carted to the spot, and in the case of a breach to the embankment, the repair is rapidly executed; a line of communication moreover throws the whole work open to public inspection, and prevents many irregularities, from the certainty of their being detected.

226. To the efficiency of these roads I have always paid great attention, in fact from the difficulties that we have had to contend with, in raising embankments, the necessity of this efficiency has been forced upon me. The east bank of the Canal is maintained as the high road from Kulsea* to Selimpoor—the road throughout the whole year is kept perfectly clear from jungle so as to be open to wheeled carriages of every description, and the berm and slopes of the Canal are annually cleared after the rains—in the South Division where the line of Canal and the berms are more compact than elsewhere, this clearance is most rigidly enforced. On the west bank I have been satisfied with keeping the internal slope of the Canal clear from grass and jungle; excepting at those points where an extraordinary height of embankment, renders a clearance necessary to prevent the inroads of vermin; this species of clearance is of importance, in the neighbourhood of Abba and Jhinderi, where the banks are high and where otters are numerous. The following diagram will shew in section the extent of clearance that I have

* The road from Kulsea to Rundole is now made on the west bank: that on the east having been broken at two points by flood inlet, which would have been expensive in the repair.

endeavoured to maintain, I look upon this as essential to the care of the works, and although I have been deterred by expense from carrying it out in parts of the Northern and Central Divisions, where the berms are wide, and covered with high grass and reeds, I have still made periodical clearances so as to reduce the evil as much as possible.

DIAGRAM 17.



From x' to x, or from the rear of the east to that of the west bank no trees nor plantations are allowed,* these are confined to the strips between the rear of the banks and the boundary ditches $a\ a$, from x' to y, the surface is kept clear of thorns and high grass, &c. The remaining portion, including the berm and the west bank, is only kept clear from trees; low jungle and high grass are allowed to remain. The road is kept in good repair, and the constantly travelling of stone rollers over it, leads not only to the temporary outlets for irrigation, (which are fortunately becoming less numerous every year,) made through the embankments, being well strengthened and protected by the cultivators, but to the diminution of evils arising from rats, white-ants, &c. I am an advocate for the constant use of heavy rollers on these banks, and am satisfied that the splendid order in which the east bank or

* At one or two points I have allowed mango and superior specimens of the larger trees to remain standing on the east bank continuing the road round them —this is especially the case near Kandla, and near the Nalla Bridge; at the latter place on the east bank there is one of the finest Keekur (acacia arabica) trees I ever saw—it measures in girth 9 feet, at the height of 4 feet from the ground, and is a tree that never ought to be cut until it dies. As the present winds are from the north west, the falling of a tree on the east bank during a storm would not interfere with the Canal channel, whereas an accident of the sort occurring to a tree on the west bank, would lead to an occurrence similar to that noted in para. 177.

road in the South Division is always maintained, has depended chiefly upon the regularity with which rollers have been used—one or two rollers ought to be established on the line between Nowrungpoor and Bynswal; one of these should run between Nowrungpoor and Berkheri, and the other between the latter place and Bynswal, the growth of Doob grass is carefully cherished on the bank, berms and slopes.

227. North of Kulsea, the road formerly ran parallel to the Canal on the right bank up to the Belka Falls—but there has been so much cutting away, and alteration to the course of the Canal on this line since it was open, that the road has been deserted; its course was through high grass jungle, the Canal channel very deep in its vicinity, running through waste land, and with no masonry works of any description to be protected. Within the last few years, however, the Falls at Behut have been constructed intermediately between Kulsea and the Belka Falls; and as the present road connecting Kulsea with the Belka Falls passes through Behut and at a distance from the Behut Falls (which without going out of the way cannot be visited,) I recommend that a road should be made as formerly, keeping as closely as a fair alignment will admit of, to the Behut Falls, and from thence on to those at Belka; this will enable the inspection and patrol to go on in its usual course; if this road is not approved of a Choki must be established at the Behut Falls, whether lockage is used or not, as at present the work is cut off from all communication except by the road from the town.

228. From the Belka Falls to the Nyashur Choki the Canal bank is in capital order, excepting on the line from Gundewur to the Nowgong River, where the original bank has been destroyed by the retrogression of levels in the Canal bed; a good road, however, has been made to the rear.

229. I have before explained (para. 25,) that the Nyashur Choki is connected with the Canal heads by good roads which

were formerly made at the expense of the Canal. This has also been done between, Kulsea and the bunds on the Muskurra, between the Hullalpoor and Pandhoi Choki, between Abba and the Bunhera outpost of the Julalabad irrigation--in fact whenever I had the means, either in money or in work people, I have made it a rule to connect the main line of the Canal with its outposts or works, in every way that I could, by open lines of road. During the hot weather when the European constitution is little adapted to exposure and less inclined to exertion, it is to me perfectly evident that by giving good roads a frequent inspection of works by Overseers is insured --a man will drive twenty miles in his buggy over a good road, when he would not go five on horseback over no road at all. I advocate strongly the keeping of buggies or carriages by Overseers, as well as by Officers attached to the Canals, it insures the maintenance of the roads in good order; want of repair is not so observable when on foot or horseback, the use of an elephant to an Officer, therefore, employed on Canal duties, in this part of India, is much to be appreciated, it may even be considered indispensable to the efficient inspection of his works, and the command which he gains for reconnoitring from the back of an animal of this sort, enables him to see defects and means of improvement which otherwise would entirely have escaped his observation. The soundness of an embankment moreover undergoes a severe test when subject to the weight of an elephant.

Bunhera outpost.

230. Supplementary to the maintenance of the Canal bank as an open and free line of communication, as well as to that of other roads connecting it to the Canal outposts, is the efficiency of the Chokies and their establishments. The whole of the first class Chokies on the Doab Canal, are not only kept in the best order but give good accommodation to the European and Native establishments; these Chokies are situated at from 12 to 15 miles apart, and as far as mere cover is concerned nothing better could

be wished for—mere cover however is not the only thing required, each building ought to have a table and two chairs, so that when an European was summoned from a distance, the means of carrying on office work might be provided, the expense of plain but strong furniture of this sort would be trifling, and the advantages great. It will be seen that by the maintenance of roads on the whole length of the Doab Canal, there can be no excuse whatever for any want of attention on the part of the European establishment, who by these means are enabled at a moment's notice to take up a position wherever the wants of the Canal may demand it. The Native establishment is, moreover, confined to the banks and to the proximity of their special duties by the above arrangements, fixed points are offered for the meeting of the Superintendent or of the Native Collectors with the Zumeendars or cultivators, and independently of the convenience offered in these respects, the roads give facilities for the conveyance of material, stores, &c., whilst the Chokies give a cover to the same, points in themselves of the greatest importance. I should regret to hear that any check was hereafter given to the system which has been adopted both by my predecessor and myself on these points—it would be a false economy either to grudge expenditure on roads or accommodation to the establishment. With regard to the clearance and maintenance of the Canal bank road, I am satisfied that the very existence of the Canal in a state of efficiency depends upon it.

Plantations.

231. The main plantations on the Doab Canal are at Nyashur and Kulsea, as before described in paras. 24 and 74, but the strip of land in rear of the embankments, and between these and the boundary ditches is devoted to plantations also. With exception to a few points between Kullurpoor and Bynswal where the bank raising has led to the destruction of young trees originally planted, the Doab Canal from beginning to end may be considered as an

avenue of trees with the channel running in the centre. Waste land in the neighbourhood of Chokies has been taken possession of in many instances; where roads cross the Canal, clumps of trees have been established on the right and left of the approach; and latterly when funds have been available, the lines of Rajbuha have been planted. Owing to the patrole passing along the east bank of the Canal, the plantations on that side are at this period much more regular, and the trees more numerous than on the other. On the west bank however there are few spots where trees do not exist, and those few will shortly be planted.

232. The annual grant for plantations on this Canal was up to the year 1842-43, 1,000 Rupees, which has now been increased to 3,000 Rupees per annum, a sum that will admit of the most extensive improvements. My successor, Lieutenant Baird Smith is now engaged in planting out the whole of the unoccupied spaces in the Nyashur grounds, and in filling up the blanks which occasionally occur elsewhere—the planting out of the lines of Rajbuha is also occupying his attention—on referring therefore to the map of the Canal and its branches, it will be seen that in a short space of time, lines of trees will ramify into all the lands between the Jumna and Hindun rivers, and an useful supply of timber will be, by these means, provided for the wants of the country.

233. The saul tree (shorea robusta) which is the wood in chief demand in this part of India (for the larger class of beams especially) is imported from the forests on the northern slope of the Sewaliks. These forests are at present unprotected, and the want of economical arrangements in checking an indiscriminate cutting of timber, has for many years, and at the present time especially, led to a great increase in price of wood of all descriptions, and frequently to a difficulty in procuring timbers of the larger descriptions. The forests on the Jumna side are nearly cleared out, and unless some means are taken by the Government the same fate will attend those towards the Ganges. To obtain a block of wood

suitable to his wants, the wood-cutter will cut down the finest tree and leave what is not required, to rot. When the timber near the root is too large, he will cut the tree down at a considerable height from the ground, leaving the stump standing. Quantities of wood are cut down and sawn up annually, in these forests, without arrangements having been made for their transport, and the wood so cut up is left either to rot during the rains, or to be destroyed during the fires when the grass jungle is burnt. Thousands upon thousands of young saul trees, which are sold in the markets under the names of bullahs and bullies, are cut annually, many of which are carried away, and as many left in the forest to be destroyed. It is perfectly clear that a system of this sort must eventually lead to a total want of good wood, unless arrangements are made elsewhere for its supply. The saul unfortunately does not appear to thrive well on the southern slope of the Sewaliks, and with the exception of teak, which is not indigenous to this part of India, it is not easy to find a substitute for it. The Canal plantations will undoubtedly in the course of time amply make up for the destruction of the Sewalik forests in toon, sissoo, &c., but although, as I have before noticed in para. 24, I have succeeded in introducing a few plants of the saul into the Nyashur plantations, which plants thrive remarkably well, owing to the care and attention that has been bestowed upon them, it may be questionable whether in an economical point of view, it would be worth while to enter into an extended experiment. I would rather turn my attention to varieties of timber trees that are either indigenous to the soil, or to those which although not indigenous appear to take to it freely—leaving the saul timber to flourish and increase in its own particular regions under proper forest supervision. The declining state of that part of the Sewalik forests situated between the Jumna and Ganges river was brought to the notice of Government many years ago by Colonel Colvin; the same was done by me in 1830, and at different periods since. The subject was taken up vigorously

by the Agra (Mr. G. R. Clerk's) Government in 1843, who recommended that the appointment of Superintendent of forests in the North Western Provinces should be vested in me, an arrangement that was disapproved of by the Supreme Government. Of the advantages of vesting the control of departments in the person of one individual who would ensure a well regulated system of management throughout that department, I can see no doubt. With reference however to the forests above referred to it appears to me that the Superintendent of the Doon is the proper person to look after their interests; as the chief civil authority he has an influence that no other individual could have—and the distribution of his native establishment at the different Chokies and posts in the forests, would give him the means of protecting their interests at a much smaller expense to the state. The Superintendent of the Doon should have the *executive management*, whilst the *controlling power* should be vested in the Superintendent of Forests, North Western Provinces.

234. The teak thrives much better than the saul tree in the northern Doab—there are many beautiful specimens of the former in the Doab Canal plantations, especially near Manukpoor and Khundraoli, and to the Suharunpoor Botanic Garden it is one of its greatest ornaments; many of the trees in the garden are upwards of twenty years old and reach to the height of fifty feet. I have seen door and window frames made of the wood cut from the Botanic Garden, and its appearance in texture and fibre was very similar to that of the teak from the lower Provinces. Near the Khandla Choki as well as that at Selimpoor there are also fine specimens of this tree. It does not however like frost, and would therefore perhaps be out of place at Nyashur and in the forests near the Sewaliks.

235. With the exception of the tract on the Canal between Khandla and Surrowli which is particularly favorable to the Keekur (acacia arabica) the plantations are chiefly toon, sissoo and

sirrus. There are a few peepul, bur, and trees of other descriptions, and occasionally those of an ornamental character have been placed in prominent situations, such as clumps of bamboo, teak, casuarina, fir, and the amultas (cassia fistula), the latter bearing a beautiful yellow flower, which at a distance resembles an exaggerated laburnum. The oldest trees in the plantations are those near Kulsea and Suharunpoor, chiefly sissoo · their present height may be from 25 to 30 feet, and girth, including bark from 30 to 36 inches : these were planted in 1827-28—it may probably take another twenty years before these trees are ready for the timber yard. I have always looked upon the toon as the most valuable of all our forest trees—and I have accordingly done every thing in my power to make it a prominent feature in the plantations, this variety of tree is abundant both in the Nyashur and Kulsea planations, as well as in those in the neighbourhood of Suharunpoor. For the purposes of timber there is no doubt that all the Canal plantations require thinning, to give that room and ventilation which is so necessary to the growth of trees. This has been done to a certain extent, especially in the Kulsea plantations, but it would be a dangerous experiment to entrust natives with work of this sort, leaving the selection of trees to be cleared to their own judgment—it would be utterly impossible to do so without running the risk of sacrificing the best trees in the plantation. The European overseers, have up to the present period, had so much work on their hands that they had no time to devote to the undertaking, the trees therefore are thickly placed together, but this gives a shade to the road bank, which during the hot weather is so grateful, that it may be doubted whether the advantages derived from shade to the Canal, is not as great as that derivable to the timber from thinning the plantations. The Mujnoon, or Weeping Willow, which grows uncommonly well at certain parts of the Canal in the neighbourhood of moisture, has been planted to a considerable extent, with a view to its being turned into use

in basket-making, I would recommend that the experiment should have a fair trial; at any rate it is highly ornamental, and flourishes at points where other trees would not grow.

236. The Keekur or Babool, which grows in abundance in the southern districts of the Canal, is the only tree from whence the Canal has derived any revenue, from its sale in the markets: this has arisen from the numerous trees of this description which existed on the berms, and between the external slopes of the east and west embankments, a space upon which I allow (with few exceptions) no trees to grow—the wood is cut down and stacked by people who contract to do this, receiving in return the bark, which is used largely in tanning, the wood thus stacked is boated down to the Selimpoor Choki, and sells at from 18 to 22 Rupees per 100 maunds in the Delhi market. There is a variety of the Keekur, of which two trees formerly existed either in the vicinity of Kukripoor or Bural; its peculiarity consisted in its branches growing at an acute angle to the stem, exhibiting a form of ramification something resembling the poplar; from seeds collected from these two trees, this variety of the Keekur has been greatly extended, and will be found at numerous points on the Canal banks.

237. I have in para. 24 referred to the "acacia superba," a noble forest tree, which has been introduced into the Nyashur plantations from the eastern Deyrah Doon, it will no doubt eventually be extended throughout all the plantations.

238. In addition to those forest trees, it is proposed hereafter that at every first class Choki there should be a plantation of grafted mangoes—the object in establishing these plantations was, that of supplying fruit of a superior quality to the towns and markets in the neighbourhood, and of forming depôts for the distribution of young grafted plants in the gardens on the banks and in the vicinity of the Canal. It is proposed that when the trees have arrived at maturity, the plantations should be farmed out, and the proceeds arising therefrom be carried to the Canal account.

At present the following plantations of mango grafts have been made :—

1st, Selimpoor.
2nd, Surrowli.
3rd, Deola.
4th, Berkheri.
5th, Manukmow.

That at Surrowli has been planted since 1842-43. The area of each is about five acres: a great portion of the original outlay is saved by using the ground for a wheat crop, a plan that may be very beneficially adopted until the trees arrive at a certain height —the grounds are laid out with walks, and protected by a fence; and are in every point of view, a great acquisition. I would recommend that plantations, similar in every respect to the above, be established at the remaining first class Chokies.

On the Rajbuha System and its progress on the Doab Canal.

239. On the opening of the Doab Canal in 1830, the cultivators appeared to consider that the only possible way they could get water for irrigating their lands, was by throwing bunds over the channel, or by pushing spurs into the stream; arrangements which were utterly objectionable; for this reason the dams formed on the escape nullas for holding up the water for irrigation (*vide* para. 115) were eagerly seized upon, and as coming under their comprehension more clearly, were instantly used by the cultivators. To facilitate the extension of Canal irrigation and to enable the people to excavate water-courses, the sum of 10,000 Rupees was placed at my disposal. The intention of the Government, at my recommendation, was that the power should be placed in my hands of advancing small sums of money, on proper security, to cultivators who had not the means, without such advances, of excavating their water-courses. It was very soon apparent that, in

many cases, the advances made by me were grossly misapplied, and in others that after expending all the money, the borrower had dug a water-course which was of no use to him; I found in short that the proposed plan was not only a waste of liberality, but a positive injury to the cultivator; that to obtain the object required was not to give an ignorant man money, but to shew that man the way how to lay money out to his own advantage; at this time moreover the evil arising from silt deposits, not only in the escape nullas, and upon their irrigation dams, was becoming apparent, but that it was a matter of certainty if the nullas were to be used as escapes at all, irrigation on their courses to the extent originally projected must be abandoned. There were great inconveniences also arising from the multiplicity of water-course heads which had been established through the Canal embankments, many of which were as far as possible from the eye of the Chokidar, and consequently perfectly uncontrolled—the road bank was dangerous from the carelessness with which temporary openings were bridged over; the waste of water was great—it became therefore a point of economical necessity to establish some system, that would in preventing the evils above complained of, give the cultivators water to greater advantage.

210. The plan that naturally suggested itself was, to persuade the Zumeendars of villages to subscribe for water-courses dug from the Canal, the excavation of which should be entrusted to the Canal Superintendent—that no advances should be made to individuals from the Canal treasury, but that on application, water-courses should be dug by the Superintendent, and the expense charged to the applicants. Finally, that the best plan to adopt would be to confine the outlets for irrigation to main lines, and from these main lines only should water be given for irrigation; that in the course of time all minor outlets should be stopped, and that endeavours should be made to carry out a plan which appeared to possess the following advantages:—

1*st*. The delivery of water for irrigation on approved levels.

2*nd*. The supplying of water to distant village lands authoritatively, and without the interference of the intermediate villages.

3*rd*. By making one main outlet act as the supply for numerous drain heads for irrigation, a more efficient control was necessarily established.

4*th*. Great waste of water was saved by getting rid of numerous outlets, and combining them into one.

5*th*. That by economising the water, and by the extension of the lines of water-course, the benefits to be derived from Canal irrigation would be more generally disseminated.

241. The general outline of the scheme was to form two lines of water-courses, parallel to, and intermediately between, the Canal and the Hindun on one side, and the Canal and the Jumna on the other; these two main or trunk lines were to be met by branch water-courses on every four miles in the length of the Canal, these branches affording irrigation to the tract through which they would pass, and terminating in the trunk line as feeders. The topographical features of the country might interfere with the strict detail above mentioned, but there was no doubt that the plan in its general sense was perfectly attainable.

242. To simplify the accounts and to ensure an uniformity of system and management, the plan of joint stock companies was adopted—the Canal officer being the director and treasurer. On the Zumeendars of a required tract having agreed to pay the expenses of a main water-course or Rajbuha, the line was surveyed and levelled, and the probable cost of excavation fixed in round numbers at from 200 to 500 or 800 rupees a mile, as the result of the survey suggested. The total probable cost was then divided off into shares of 25 rupees each, which shares were distributed amongst the applicants in proportion to the benefit that each would

derive from the work. These applicants were denominated "Awul Hissadars," or original shareholders, and were to have the advantage of obtaining a refund by the after purchase of shares by Zumeendars and others, who declined in the first instance to enter into the scheme, but who when they saw the water-course completed were desirous of becoming shareholders; the latter were called "Hissadars," and the amount that they were called upon to pay for each share, was to be never less than 50 Rupees—the money so collected was carried to the account of the "Awul Hissadars," and was either to be refunded in cash or put to their credit in the repairs or improvement of the work.

243. Each holder of two shares was to have one outlet of 10 × 8 inches, or 6 inches square, or smaller, if necessary—a matter depending on the slope of country and to be settled by the Superintendent. In the case of one share only being taken by a village, the size of the head was to be determined by the Superintendent.

244. These water-courses were to be bridged and embanked, and one embankment with the inner slopes of the channel was to be kept clear of jungle, to admit of the passage and inspection of the Chokidars, and to enable the Superintendent to pass without interruption from one end of the line to the other.

245. Chokidars, and if necessary Chokies, were to be kept up at the expense of the Rajbuha.

246. The annual repairs were to be made by the Superintendent chargeable to the Rajbuha, and payment called for both from the "Awul Hissadars" and the "Hissadars," each paying a quantum of the expense in proportion to the number of shares held.

247. Supposing therefore that a Rajbuha is proposed, of five miles in length, the estimated cost, including masonry bridges, being 800 Rupees a mile, or 4000 Rupees, the following villages having agreed to undertake the work, an examination of these lands shews that shares may be told off as follows:—

	Shares.		Rs.
Kheri, ...	20 at 25	Rupees, =	500
Kukra, ...	40 at 25	„ =	1000
Khunjoori, . . .	40 at 25	„ =	1000
Nundipoor, . . .	50 at 25	„ =	1250
Rujwa, ...	10 at 25	„ =	250
Shares, ..	160	Total Rs.	4000

Should the actual cost be under the estimate, and admit of a refund of even shares to each village, such refund is made: if not, the fractional balance is carried to account of the Rajbuha; should the cost exceed the estimate, the excess is called for from the shareholders in sums amounting to equal additional shares, the balance in excess to be carried to account as before.

218. The cost of annual repair is settled thus, taking the above Rajbuha for example; an advance is made from the "Tukkavi" account—and when the repair is completed it amounts, say to Rs. 150-8-8—which is charged to the shareholders $\frac{150\text{-}8\text{-}8}{160}$, or a fraction more than 15 annas per share, 16 annas, or one rupee per share is therefore taken, and the balance carried to account; should, however, the balance existing in the office be in favor of the Rajbuha, allowances are made, but fractions of annas are rejected.

219. The above is an example of a Rajbuha confined entirely to original shareholders—but supposing that, after the work had been completed, four other villages had expressed a wish to join, and that the required number of shares, required to suit their purposes, were thus:—

	Shares.		Rs.
Gurdunpoor, . .	2 at 100	Rupees =	200
Nugla, ...	3 at 100	„ =	300
Shorujpoor, . . .	3 at 100	„ =	300
Leelpoor, . . .	2 at 100	„ =	200
Shares, . . .	10	Total Rs. ..	1000

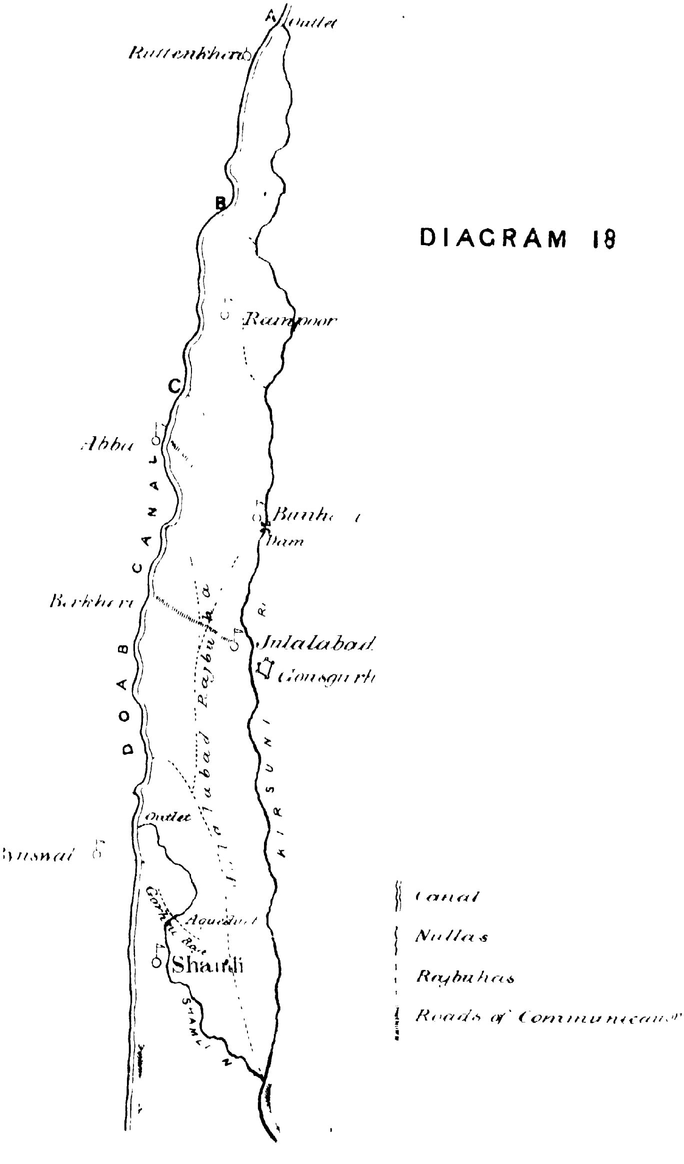
or equal to 40 original shares at the fixed rate of 25 rupees each.

This one thousand rupees would be refunded to the "Awul Hissadars," that is to say, they would recover one-fourth of their original outlay—and the additional shares, amounting to 40, at the rate of 25 Rupees each, would reduce the amount which each has to pay for repairs; the number of shares now being 200, and the annual cost of repairs; as above, amounting to 150-8-8, we have the share of each thus, $\frac{150\text{-}8\text{-}8}{200}$, or a fraction more than 12 annas instead of 15 annas, as in the former case. Should other villages come forward afterwards, a refund is made in a similar way to the "Awul Hissadars," (and to no others) who may, in the course of time, derive a benefit from their spirit of enterprize in establishing the work, by getting a refund of the whole of their money, and having to pay but a small sum for the annual repairs.

250. As separate books are to be kept with each Rajbuha, and also a running account, considerable additional labor is entailed on the Superintendent's office,—this ought ere long to be met by additional Writers and Accountants.

251. The masonry heads or outlets for the Rajbuhas from the Canal have been generally made at the expense of Government, I think that this ought always to be done, although, in some instances, I have charged them to the Rajbuha account. There are cases also in which Government may fairly pay a part of the expense of the Rajbuha itself, that is, where very heavy works, such as aqueducts, extensive cuttings or embankments have to be made, to render it possible for the water-course to reach distant lands and benefit them by irrigation. I have always found the Military Board ready to recommend works of this sort, the Nugla Rajbuha, for the first four miles, extending from the Canal to the Dumola River, together with the masonry aqueduct on that river, were built at the expense of Government, *i. e.* that of the General Canal funds. The reasons for recommending such a step were, that no benefits could be derived from the Rajbuha until it reached the left bank of the Dumola, Government therefore having delivered the

DIAGRAM 18



A
Outlet
Ruttenkhera
B
Rampoor
C
Abbu
DOAB CANAL
Dam
Berkheri
Julalabad Rajbuha
Julalabad
Gonsgurh
AIRSUNI R.
Outlet
Aqueduct
Shamli
SHAMLI N
Canal
Nullas
Rajbuhas

water to this point, left the Zumeendars to do the rest. In approving of the prolongation of the Kullurpoor Rajbaha, a masonry aqueduct on the Kirsunni has been authorized—numerous instances of this sort have occurred, and as far as I can recollect only one recommendation was ever negatived, viz. that the shareholders of the Khekra Rajbuha should be relieved from the expense of some very heavy embankments, which were necessary to conduct the Rajbuha to distant lands, which would be greatly improved by such an arrangement. I have made it a point that masonry bridges alone shall be permitted on Rajbuhas, they may be a little more expensive at first, but they require little repair afterwards, and the Canal establishment has quite enough to do on the main line without having anything additional to distract its attention elsewhere. With regard to the interference of the Canal Rajbuhas with the main lines of road under construction by the Road Committees, I have always built bridges at the expense of the Rajbuha when crossing a road already lined out or completed; but when a road made by the Road Committee crosses a Rajbuha previously made, the Committee has been called upon to pay the expense. Some fixed rule or other must be acted upon, and this appears to be the most reasonable. When a Rajbuha however crosses a high line of Military road, the Government has never objected to pay all expenses of a bridge, on the submission of a proper estimate.

252. It is unnecessary here to enter into a detailed description of the Rajbuhas already executed, they have been referred to in detail of position in a former part of this paper—it will be sufficient to describe the Julalabad series, which is more complete than the others, and from this a general idea will be formed of the whole. The following diagram *(see opposite page)* is explanatory of the relative position of the Canal, the Kirsunni River, and the Shamli Nulla, and the different Rajbuhas composing the Julalabad chain.

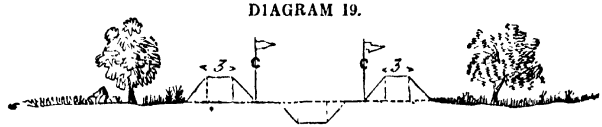
The whole of the water thrown into the Kirsunni at the outlet A and the Rajbuha heads B C, is caught up by a masonry dam

thrown across the nulla at Bunhera, from whence it is carried over the high land towards the junction of the Kirsunni with the Shamli Nulla; it is intended hereafter that a corresponding branch shall be made on the left bank from the Bunhera Dam, a head for which has already been constructed. The whole of this Julalabad chain has been completed, with exception to the line after the junction of the Gorhni water-course, but it is still open to improvement by additional feeders from the main Canal.

253. From the quantity of sand floating in the Canal water, these water-courses are liable to deposits more or less severe, depending on the slopes of their channels, and the position of their heads, they therefore require much attention and periodical clearances, and unless these are systematically attended to, the greatest interruption exists to irrigation—these deposits only take place within 3 or 400 yards after the departure from the Canal, and at a quarter of a mile cease entirely. It has been found convenient however, in fixing upon the site for a Rajbuha head, to select that, where the country on the outside and near the Canal bank is low, this admits of a space for throwing the sand (cleared out from the course of the Rajbuha) upon, without making heaps and irregular mounds, which are so disfiguring to the works.

254. The transverse section of a Rajbuha is as follows—the width and dimensions depending of course upon circumstances, the top or terreplein of the embankments is always 3 feet wide, to admit of a free passage, the whole is put into proper form, and an annual clearance of one bank, the bed and slopes is rigidly enforced. Trees are planted on the outside of the embankments, and waste land in the vicinity of bridges, is either converted into nurseries or plantations.

DIAGRAM 19.



The declivity of bed is carried on one uniform level, on slopes varying from 10 to 30 inches per mile—the most common slope is 18, but I prefer 24 inches to a mile. As I have before said, all bridges and work on these lines are of masonry, a rule laid down to prevent trouble from after repair, or disarrangement from the failure of temporary works. By referring to Diagram 18, it will be observed that, by closing six heads, the Canal authorities have the power of stopping the whole of the Julalabad irrigation; had this irrigation been taken, (as in the original plan it would have been) from the main line in separate water-courses for separate individuals, we should have had in all probability 300 outlets, the greatest number of which would have been removed from any control whatever.

255. The papers in Appendix, exhibiting a list of the irrigation heads on the Canal on its whole line, even at this time, shew that the temporary outlets are very numerous. I would urge my successors not hastily but gradually, and by extending the plan of the Rajbuhas, to get rid of these temporary heads entirely, I would not permit one to remain either on the east or west bank of the Canal, and if fair persuasion and reasonable argument would not induce the Zumeendars to combine in entering into the Rajbuha system, I should after six months' notice remove the whole of their outlets, repair the banks, which wherever these temporary heads exist, have been much injured—and wait leisurely until applications for Rajbuhas were made.

256. Upon many of these lines of main water-course, machinery for grinding corn might be established with great advantage both to the Canal revenue and to the convenience of the community—it is an object however to economize water and not allow it to run waste into the low beds of rivers, I should therefore be disinclined to establish Mills on the Rajbuhas unless the tail water could be brought into use afterwards in irrigation.*

* In a letter which I addressed to the Secretary to the Governor General,

257. I cannot conclude the subject of this chapter, without adverting to the great and ready assistance that I have always received from Mr. Sub-Conductor H. B. Brew, the Overseer in the South Division, under whom the whole of the Rajbuhas not only in his own line, which extends from Shamli downwards, but also in some instances in the Centre Division have been executed. This assistance has not been confined to the mere superintendence of the excavation and building of masonry works on plans and levels laid down for his guidance; in some cases lines have been entirely projected by himself, profiles of country, and designs for the slope of the channel have been submitted by Mr. Brew, and the works have been executed on these plans and levels much to my satisfaction. The admirable state of efficiency and order moreover in which all the Rajbuhas in the South Division are maintained, according as it does with that of all the embankments and works on the main line of the Canal under this Overseer's management, makes him deserving of a much higher reward than the mere acknowledgement by me of his value as a public servant.

On the Works and Collections—European and Native Establishment, &c. &c.

258. The Doab Canal works are separated into three Divi-
Works. sions as follows :—

1st, or Northern Division, from the Head to, and including, the Ghoonna Falls.

2nd, or Centre Division, from the Ghoonna Falls to the Mundait Bridge.

North Western Provinces, dated 24th May 1838, I drew the attention of Government to the value that might be derived by making Rajbuhas upon Dumoth Hindun, West Kallee Nuddi, and other perennial streams in the Doab—this was approved of, and the sum of 3000 Rupees was placed at my disposal for the construction of one line as an experiment. although nothing was done, in consequence of my time being occupied with other matters, the project is well worthy of consideration.

3rd, or South Division, from and including the Mundait Bridge to the tail of the canal at Selimpoor.

An European Overseer is attached to each Division, with a Mootsuddie and Native Establishment—his duties are solely confined to the works in either construction or repair, and for the efficiency of which he is responsible.

The Assistant Executive Engineer has executive charge of the Centre Division, and conducts all duties of this Division under the orders of the Executive Engineer—my object in this arrangement was to make the Assistant acquainted with all the routine of management, so that were he suddenly called upon to take the place of his superior, matters might be carried on systematically. I have always made it a rule to give to an Assistant, as early after his joining his duties as possible, the construction of both embankments and masonry buildings without the aid of an Overseer, so that he might learn the practical detail of the manufacture of materials, building, accounts, rates, &c.—and become acquainted with difficulties which, without this practical experience, he would not be able to appreciate. The best works on the Canal have been built under this management, and I believe that every young Officer who has been subject to it, is satisfied, that he who has done the duty of an Overseer himself, is best able to superintend and appreciate the labours of an Overseer.

259. At each of the masonry dams, escape heads and regulating bridges, are establishments consisting of a Mate and Bildars, proportionate in number to the duties demanded from them, these establishments are permanent, and their members are required to make themselves acquainted with the management of the gates, windlasses, sleepers, &c., to be ready on emergency at all times, and are provided with cover in the immediate neighbourhood of their respective works, so that no excuse may be alleged for not being in attendance. At each of the Chokies are Chokidars, who, in addition to their duties in supplying water for irrigation, and

looking after the water-course heads, are called upon to patrole the banks daily, to report on any irregularity, and to inform the Overseer when repairs are required; each of these Chokidars is armed with a heavy stick with iron ferrules, for the purposes of beating in rat holes and knocking away the mounds made by white ants—this class of establishment is partly connected with the department of works, and partly with that of the collections. At each of the first class Chokies, a Chuprassi is posted, for the protection and preservation of the building, but he has charge of the bridge, plantations and works immediately in the vicinity of his Choki; this man's services are confined to these special duties, and he is not allowed to be detached. At each of the Corn Mills also a Chuprassi is placed, whose duties are in every respect similar to those at the Chokies.

260. Reports of progress of works performed are submitted weekly by each Overseer to the Executive Engineer, these contain the length of embankments repaired or cleared, length of channel excavated, and masonry work completed, with quantity of cubic feet done during the week. Accounts are sent in monthly exhibiting an account current of cash received and expended, with vouchers for each debit, showing the number of labourers employed daily on each work, together with the daily expense, as well as that of materials; payments made to establishment, contractors, or others, are vouched for by receipts, which are appended to the accounts; these are sewed together, and at the end of each year, viz. from January to December, are bound in volumes, each Division of works being kept separate and lodged in the office for record. In constructing buildings, Overseers are particularly called upon to leave the working plans in the hands of the Head Mason, Mistree or Mootsuddie *on the* work: and when the whole is completed these plans are to be returned to the office with the last account submitted, with any remarks, which the Overseer has to make, recorded on the face of the plan.

261. The collection of revenue on the Doab Canal is placed in the hands of four Native Agents or Zillahdars, whose districts are as follows:— Collections.

1st,—or North-Suharunpoor District, from the Head to Balpoor.

2nd,—or South Suharunpoor District, from Balpoor to Bynswal.

3rd,—or Moozuffurnuggur District, from Bynswal to Barote.

4th,—or Meerut District, from Barote to Selimpoor.

The duties of the Zillahdars are confined entirely to collections—they correspond direct with the Executive Engineer—and in the management and distribution of water for irrigation they are assisted by the Chokidars at the different Chokies, each of whom has a separate tract of villages for the irrigation of which he is responsible. All penalties for breach of Canal Regulations, amount of sale of Canal produce, mill rent, transit duties, and minor items of returns are reported by the Zillahdar to the Executive Engineer in a half monthly list in detail, which being approved of, a warrant is issued under the hand and seal of the Executive Engineer, for their collection. This list contains every item of Canal revenue, with exception of water-rent for land irrigated, which is submitted half-yearly at the conclusion of the Rubbee and Khurreef crops.

Rent on Land Irrigated.

262. The return of land irrigated is obtained by superficial measurement, agreeably to a scale of rates as noted in the Appendix. For the purposes of this measurement there is an establishment of a Darogah, with Mootsuddies and measurers under him. During the period that each District is undergoing measurement, the Zillahdar and Chokidars attend upon the Darogah, to assist him in pointing out the lands irrigated by the Canal, on the conclusion of the measurement of a District, the Darogah sends in to the Executive Engineer's office, a statement of the area of each

field irrigated in each village, noting the variety of crop and rate of charge, as per scale beforementioned: the returns on each village are on separate paper, and having undergone examination and check in the office, a separate warrant is drawn up for the collection of the amount, and this warrant is forwarded to the Zillahdar, under the seal and signature of the Executive Engineer. The Darogah therefore has nothing whatever to say to the cash collections; he is considered to be superior to the Zillahdars in rank, as well as in salary, and is called upon to report on his periodical inspections any irregularity that may come under his notice. The cash collections are all vested in the Zillahdars of Districts.

263. The system adopted on the Doab Canal is that which was drawn up by Colonel Colvin and authorized by the Government, and from the experience that I have had of it, I see nothing that requires material alteration. It is absolutely necessary in a work of this sort to lay down fixed rules with regard to property, and although it may appear absurd to visit with condign punishment a member of the establishment, who cooks his dinner from fire-wood taken from the Canal plantations, or who feeds his cattle with grass taken from the Canal banks, the principle of such an arrangement is that of 'Perquisites,' to which there appears to be no definite limit, the limit generally depending on the conscience of the taker. To prevent therefore the operation of the rule that "what is nobody's property is every body's property," it is considered that the whole is the property of the State, and to secure this, the Canal banks are farmed out to contractors (in portions generally bounded by bridges,) who by paying a certain sum, which is carried to account in the Zillahdar's half-monthly statement, are on certain conditions owners for the time being of the grass and refuse on the banks. The Zumeendars of the estate through which the Canal runs have always the refusal of that portion

Perquisites repudiated.

limited by their own boundaries—and as the sale takes place, by open auction, the field for competition is free. It is astonishing to observe the annual amount derived from these sales, and the return to the Canal Treasury from the sale of articles which would appear to have little value, and which otherwise would be absorbed by perquisites; this will be observable by reference to the Canal Returns under the column of "Sale of Canal Produce." The only portion of the banks which are not sold (for want of purchasers) is that north of Kulsea, in the jungle tracts where the Canal boundaries are chiefly covered with high grass and reeds, with which the country away from the Canal abounds; time, however, in leading to the extension of cultivation, will raise the value of the Produce of the Canal banks even in these regions—the same may be said elsewhere; on reference to the column before alluded to, the gradual and annual increase to the sale of produce is sufficiently remarkable, and I have no doubt that this will proceed still further.

Rent on Water Mills.

264. The mills in use on the Doab Canal are merely for grinding corn, and the machinery is the simple little horizontal wheel used by the Natives of this part of India, somewhat improved in the setting up, and arrangement of its parts, with mill-house and store-room attached—these mills are put up by auction annually and sold to the highest bidder that can give security for the payment of his rent. By far the most profitable return on outlay is derivable from this source, and mills are of so much convenience to the people that they ought to be established at every point, where a fall of country will admit of it. The following shews the rent levied on the mills at the period of my writing this Report:—

Per Day.				Per Month.			
Belka, ...	0	12	0				
Nugla, ...	0	14	0	Fyzabad, ...	1	0	0
Ghoonna, ...	2	1	6	Nyashur, ...	9	0	0
Suharunpoor, ...	10	2	0	Under repair.			
Do. Botanic Garden,	1	6	0				
Shamli, ...	6	0	0				
Selimpoor, ...	9	4	0				

In the jungle tracts, north of Nyashur, the inhabitants are allowed to fix their own mills paying the trifling rent of rupees 1-8-0 per month.

265. In endeavouring to use undershot wheels adapted to Corn Mills I failed completely, both at Belka and in the Botanic Garden at Suharunpoor; the native miller was constantly putting the machinery out of order, and the interruptions to the mills were so frequent, arising from the distance at which they were situated from our artificers that latterly no tenants could be procured. Applicants (of which there were no want) looked with dismay on the machinery so different from their own, and declined entering into contracts for mills that were different to those that they had been in the habit of using—and so much trouble was given to the European Overseer already overworked, that it was found advisable to give the matter up, and establish the native mill, which found a tenant immediately. I am not at all an advocate for holding back from improvements of this sort, admitting even that the European water-wheel arrangements are better than those of the natives of this part of India; but I am satisfied that it is useless to attempt the introduction of complicated machinery, where there is no shop, no artificers, and in remote regions where the people of the country are unaccustomed to its use—the little native mill has only simple motion, a fall of water on an horizontal water wheel, with a vertical arbor passing through the mill stones, does all that is wanted—little repair is ever required, and that little is

done by the miller himself. I do not at all mean to argue that the power and quantity of water required for the native mill would not with European machinery do much more work; but that in the present state of the Canal establishment, and with the means that we have at our disposal, the native mill is by far the most convenient, and in some positions perhaps the most applicable. There are considerable funds now at the disposal of the Executive Engineer for building mills; I should recommend that two at least should be built at Selimpoor in addition to those already constructed and others may be established on Rajbuhas where the tail water would pass onwards for irrigation; there is an objection (as I have before alluded to in para. 104) to allowing the escape water to pass off to the deep beds of nullas, as at the Suharunpoor and Shamli Mills. I need hardly allude to the water power offered by the descents of masonry over which the Canal passes in the northern and southern regions of the Canal; in the absence of steam engines, the Falls at Belka might well become the nucleus of an Indian Manchester or Birmingham.

Rent on Watering Cattle.

266. This is an item of no consideration on the Doab Canal, but it is useful in giving us the means of rewarding villages who use water for irrigation, by remitting the trifling charge authorized, wherever the village pays into the Canal Treasury 100 Rupees per annum for land irrigated. To villages of this class there is no charge made for watering cattle, and the tanks or ponds attached to them are filled with water gratis. Where villages do not use the Canal water for irrigation, or who do not pay 100 Rupees per annum for land irrigated, rent is levied as per regulation, and payment is required for filling tanks.

Rafting Timber, Transit Duties.

267. This item has been before referred to in paras. 147 to 154—it has been much interfered with by the silt deposits, but will eventually when the improvements which have been recommended are carried out, be a considerable addition to the Canal Returns. The table of rates is shewn in Appendix,—when the use of boats is established, additional rules and regulations will be required :—in the mean time, the duties now levied appear to me to be fair and equitable.

Fines for Breach of Canal Regulations.

268. I am inclined to the supposition that the total annual amount of this item may be considered as the gauge by which the value of the Canal in its increase or decrease to irrigation may be tested, the fines for trespass of cattle, stealing grass, &c. are trifling to those connected with the control of the water, and as irrigation extends, so will the breach of Canal Regulations extend, and the greater the demand for water the more numerous will be the fines—these in most instances are levied on Zumeendars who to irrigate their lands before those of their neighbours, establish bunds over the Rajbuhas for which in some cases a penalty of 50 Rs. would be a small compensation ; establishing new outlets in excess of those admitted by the Rajbuha Regulations is another fruitful source of penalty, and taking water at unlawful times, and when irrigation heads have been closed by authority is another and by no means an unfrequent cause of fine. Nothing can be more just than fines for offences of this sort, if they are properly proved. The offender in either one or the other of the cases above quoted, not only disobeys the regulations, but to benefit himself (especially in the case of the bunds over Rajbuhas) does so at the expense of other Zumeendars, who have equally paid for the construction of the water-course—it is in fact robbing them of their property,

and in my opinion can only be checked by the heaviest penalty. Under the system of farming out the Canal banks, the property so farmed out becomes that of the farmer, the Canal Officer therefore in fining trespassers who steal grass and Canal produce, is merely doing his duty, and protecting the farmer. It may be here remarked that there is a great advantage in farming out the banks to the Zumeendars of the village through whose lands they pass, in the interest which the Zumeendars naturally have in protecting their own property and consequently in this case, of protecting the Canal.

269. It will be understood, however, from what I have before explained, that the only Canal Officer, who has the power of levying rent or taking money is the *Zillahdar of the district*,—that every item of money so taken is included either in the half monthly list of miscellaneous collections, alluded to in para. 261, or in the lists of beegahs irrigated as in para. 262: that these two papers alone embrace every item; and that these only are acted upon, on a warrant under the hand and seal of the Executive Engineer—Abstracts from these papers are made up monthly and half-yearly in the Canal Office, so that there is no difficulty whatever in making references.

Encouragement of the Planting Mangoe Topes advocated.

270. The natives in planting mangoe groves use the ground for wheat and other crops for many years after the young trees are planted, and agreeably to the scale of rates leviable by regulation, these crops ought to pay a higher rate to the Canal being included under the head of fruit trees. As it appears to me desirable to hold out every encouragement to the people to extend the plantations of mangoes, I have made it a rule to class gardens of this sort merely under the head of the crop whether wheat or barley which is sown, leaving the higher rate to be levied when the trees bear fruit: vegetable and garden produce, however, are not allowed on these terms.

European Establishment and Recommendations for Improvement.

271. I have before explained in para. 258 that the three Divisions of the Doab Canal works are placed under the management of Overseers, the Assistant Executive Engineer having the control of the Centre Division. The present European Establishment is as follows:—

1 Executive Engineer.	2 Overseers.
1 Assistant ditto.	2 Assistant Overseers.

The North Division is 25 miles in length, with branch works on the Muskurra, independently of Rajbuhas, which extend to a considerable distance from the line of the Canal. It is impossible when reflecting on the numerous masonry and other works in this part of the Canal, their proximity to the forests, and the consequent liability to sickness of the people attached to them, not to be struck with the necessity of an increased European establishment, not merely to carry on the duties efficiently, but to provide against casualties either in sickness or in death, which might (as it has done frequently during my executive charge) leave these works upon which the maintenance of the Canal supply depends without any European aid. This was so forcibly brought forward in 1844, when the sickness of the Overseer in charge of this Division threw the whole of the duties upon the Executive Engineer, during the height of the rains, and when his time was already fully occupied, that an Assistant Overseer was allowed for the purpose of being attached to the North Division, so that by learning the duties he might in future be of some sort of assistance in the event of the absence of the Overseer. To those who are unacquainted with the peculiar demands made upon the time and faculties of an European, by the works in the Northern Division of this Canal, the necessity frequently of being exposed during the day in heavy rain, or having to visit the bunds and dams at all periods of the

year, to oppose by his own energy, skill and quickness in resources, an element at any time the most difficult to contend with, but in the case of the mountain torrents opposed to his numerous and difficultly situated works, requiring the utmost steadiness and decision of character. To those I say who from not knowing, cannot appreciate the duties of this post, one person may be considered as good as another, and a man who has been all his life building barracks and bells of arms, may be as efficient as a first-rate Canal Overseer. This, however, not being precisely the case, it appears necessary to hold in our own hands a nursery for the education of Europeans, to enable us when casualties do occur, to replace those casualties by men who not only know something about the duties to which they are called, but who can without grumbling and without being dissatisfied reside in the district, away from society, and separated altogether from the enjoyments of social existence; this is a point too little considered in the case of the Canal Europeans, their salary which was a handsome and liberal one formerly, has been reduced, the same has been done to the salary of the Assistant Executive Engineers, whose salary has also been reduced from 250 to 200 Rupees per month. The consequence is that there is not the slightest pecuniary inducement to lead men to enter into the Canal Department, and be cut off entirely from the enjoyment of a cantonment life. It is a fact well known to the Government that the Canals in the North Western Provinces are so closely connected with the realization of the revenue of the Estates coming under their influence, that any mismanagement or interference with the required supply of water for irrigation, leads to a most ruinous loss to the State: that the Government has in fact pledged itself in the late assessments to maintain these Canals efficient; and to do this, the first thing is to maintain a *sufficient* establishment, and the next thing is to make it worth while not only for good (that is to say *useful*) men to enter into the Department, but when *in* to remain *there*. This remark is applicable both to

Executives and to Subordinates, but it is to the latter I am desirous of now drawing attention.

272. The admission of an Assistant Overseer in the North Division is one point gained, but a solitary individual may by chance be incapacitated from the duties, either from want of intelligence, steadiness or physical strength, I would therefore have three men of this class, and I would arrange the European Establishment on the Doab Canal in the following way:—

North Division, ...	1	European Overseer.
	1	Assistant ditto.
Centre Division, ...	1	European Overseer.
	1	Assistant ditto.
South Division.	1	European Overseer.
	1	Assistant ditto.

Giving an excess on the present number of two Assistant Overseers; the duties of the three Divisions are remarkably different, those of the north being almost entirely confined to the management of the numerous works, and to the maintenance of the Canal supply—those of the centre to the repair and maintenance of the very heavy embankments in that Division, and those of the south being more intimately connected with irrigation, in the superintendence and management of Rajbuhas—the difference of employment is so great, that there is an ample field for testing the value of the European subordinates—and it will probably be found, that out of three young Overseers, one may be adapted to the duties of the Northern Division.

Centre Division of Works.

273. The length of the Centre Division is about 53 miles, but it embraces all the Julalabad irrigation, besides numerous Rajbuhas, which extend considerably east and west—the latter are under the management of two very intelligent Mootsuddies, by name Kunnyalal and Bunsilal, to the former of whom especially, great

praise is due for not only the managemant of the works under his care, but for the zeal and indefatigable industry and attention, that he has always shewn in extending the Rajbuha system, and in attending to the wants of the cultivators. This man's salary is only eight rupees per mensem!—but as a reward and an inducement to him to continue his labors, he is allowed to draw two rupees per month from each of the Rajbuhas under his management. For men of this class a second rate Zillahdarship might, with great advantage, be established. It might be entitled "Naib Zillahdar," the salary not to exceed twenty-five rupees per month, that of the Zillahdar being limited to fifty rupees, the salary, however, to be eight rupees per month during his initiation into his duties, and subject to a gradual increase on good behaviour as well as to promotion to the higher grade of Zillahdar.

South Division of Works.

274. The South Division is about 62 miles in length, I have in para. 257, adverted to the state of this Division under Mr Sub-Conductor Brew's management. When the executive charge, of the Deyra Dhoon water-courses, and afterwards of the Ganges Canal works, were vested in me in addition to those of the Doab Canal, I found it impossible to do justice to the cultivators at a point so far removed from the centre of my operations; the management of all the irrigation, distribution of water, and control of the Rajbuhas in the South Division, were therefore given to Mr. Brew. The results as shewn by the increase of revenue, and the order in which the whole of the Division is kept are the best proofs of his capabilities. The loss of this Officer to the South Division would be a serious one, he is here in his proper element, he has not health to admit of his carrying on the exposed duties of the North Division, and he is so perfectly acquainted with both the works and lines of irrigation under him, that no better arrange-

ment can be made, than leaving him, as at present, where his services can be fully appreciated. On a former occasion when called upon to submit names for the appointment of Assistant Executive Officers on the Ganges Canal, Mr. Brew's name was one of those recommended by me—I should however much prefer seeing him appointed to the Doab Canal, and I hope that he may be so as an Assistant Executive Officer—Government will never regret having made such a selection; Mr. Brew would then hold the South Division as Assistant with Overseer's duties and an Assistant Overseer under him. This arrangement, it will be observed, gives no additional European aid beyond that noted in para. 272.

Canal Repairs—Material and Recapitulation of Works required.

275. The masonry works undergo an annual repair immediately after the rains, and the clearance of embankments from grass and jungle commences annually on the 1st of September. With regard to the repair of embankments, especially that part of it which embraces the stoppage of rat holes and filling in of cracks and fissures, I have found that the only way to ensure careful repair, is by sending working parties in the first place without either phaoras or baskets, but simply armed with rammers roughly pointed, with which they knock off the angles and beat in the holes—when this has been done between two bridges, parties are sent with phaoras, rammers and baskets to fill in and repair with earth. Whenever parties are sent in the first instance with phaoras, they invariably throw earth upon a hole, and smooth it off superficially—the soundness of an artificial embankment depends greatly on attention to minutiæ of this description.

276. At each of the masonry dams,* a supply of 10,000 maunds

* This does not apply to the Dams at Fyzabad and Nyashur, where the beds of the rivers consist of boulders.

of river stone or boulders, with at least 300 kurries or toors, and an equal number of spike nails ought to be kept in store, to be in readiness in case of emergency.

277. At each of the masonry falls a supply of 3000 maunds of boulders or kunkur, with 100 kurries or toors, and an equal number of spike nails, ought also to be kept in store; and whenever an expenditure takes place, the quantity expended ought to be made good as early as possible. The same applies to the Kheeri escape and the tail of the Selimpoor Mills. Attention to this point may be the means of saving a work from destruction, and it appears to me not only to be one of the greatest importance, but of such absolute necessity, that the Superintendent of Canals should enter the state of these depôts of material, in his Annual or Periodical Inspection Reports.

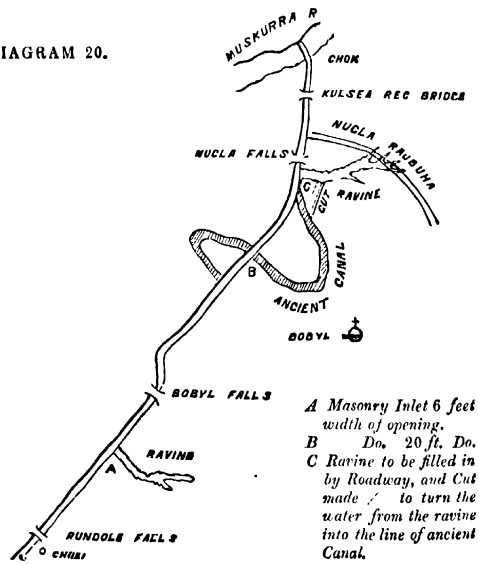
278. A large supply of spike nails ought always to be kept for distribution in the workshop at Kulsea; and at works where frame boxes are used, spare boxes ought to be kept in store; the only way to oppose an accident is to anticipate it, and under this view of the question, it would be desirable to continue the brick manufactures at Kulsea, until a supply of 10 or 12 lakhs is collected—the Dam on the Muskurra, although *it may* be sustained under the difficulties of position in which it is situated, is not to be depended upon.

Restoration of the East Bank Road from Rundole to Kulsea.

279. I have in para. 226 noted, that the road which on the whole line of the Canal, is continued on the east bank, is between Rundole and Kulsea, at present removed to the west bank, which is a great inconvenience from the want of shade. The alteration arose from the breakage of the east bank opposite Dabki, at which point a small masonry drain, which had formerly been built, was carried away, and from the inlet of the ancient line of Canal op-

posite Bobyl—at both these points masonry inlets, one of 6 feet and the other of 20 feet in width, ought to be constructed, the bank near the east revetment of the Nugla Falls ought to be renewed, and the water which flows towards the Canal down the ravine (the head of which is turned by the Nugla Rajbuha) ought to be thrown into the old Canal near Bobyl by a cut. This cut was made on a former occasion, but its capacity was not sufficient, it ought to be at least 20 feet in width, and excavated on levels accurately determined—this inlet in rear of the Nugla revetment is a more formidable evil than it appears, and requires to be attended to. The following diagram will explain the proposed works for the restoration of the east embankment, as a line of road from Rundole to Kulsea:

DIAGRAM 20.



A Masonry Inlet 6 feet width of opening.
B Do. 20 ft. Do.
C Ravine to be filled in by Roadway, and Cut made to turn the water from the ravine into the line of ancient Canal.

The east bank between the Nugla Falls and the Kulsea Choki, especially opposite the village, requires a good deal of repair—a portion of this however, might be done by the establishment of Bildars, at seasons when their services at the Dams were not required.

Tails of Works to be frequently inspected, and if necessary repaired.

280. I have before alluded to the necessity of taking possession of every opportunity to examine, and, if necessary, repair the tails of the Dams and Falls; whenever the Canal is laid dry this ought to be done; and occasionally the Canal ought to be laid dry on purpose to admit of the examination.

Clearance out of the Canal Channel between the Masonry Falls referred to.

281. In para. 213, I have explained that, although the levels of the Canal are connected by fixed points at each of the Falls, the bed of the Canal intermediately has not been touched—in cases therefore where a bar of earth intervenes upon which the current appears to have little action, opportunities ought to be taken when the Canal is dry to clear it out by excavation—this is required between Reeree and Balpoor, and especially in the line opposite Shamli, *vide* para. 157.

Bridge Ramps.

282. Some of the Bridge Ramps are in very bad order, and I would recommend that those at the following bridges should be made on a plan formerly adopted at the Deola Bridge, viz. by raising the Ramps on a slope of two feet in each hundred, from the flooring on the crown of the arch until it strikes upon the country, and raising the wing walls and pillars of the bridge to accommodate themselves to this improved slope:

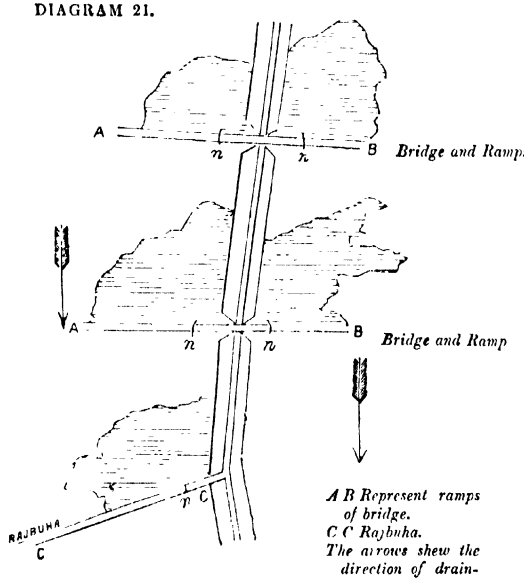
Burragong Bridge.	Baoli Bridge, South.
Khutta ,,	Bural ,,
Basode ,,	Nalla ,,
Bichperi ,,	

The cost at each bridge, including masonry drains through the ramps, would be about 350 Rupees, and the total expenditure on the above seven bridges would be 2,450 Rupees.

Under-drains for Country Drainage both at Bridge Ramps and at the Heads of Rajbuhas.

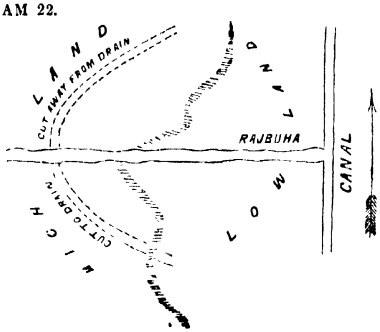
283. With reference to the masonry drains alluded to in the last para. I would here advert to the urgent necessity of similar works being constructed at the heads of Rajbuhas, especially where the embankments of these lines of water-course pass over low land. As the drainage of the country through which the Doab Canal passes is parallel to the lines of embankments, it is evident that every Bridge Ramp or Rajbuha head, acts as a Dam and leads to the collection of sheets of water more or less extensive. The following Diagram will shew the position of inundations arising from these causes, and the value of under-drains as a remedy:

DIAGRAM 21.



284. On the upper side therefore of each Ramp, or Rajbuha, an inundation is formed after every heavy rain, which can only be got rid of by escapes or masonry drains laid at a proper level under the embankments at *n n n*. The construction of these works would not at all interfere with or stop the flow of water in the Rajbuhas; the level of the lowest part of the inundated line being obtained, the drain itself might be built at a distance, and at a time when the water in the Rajbuha might (during the operation) be turned, the flooring then of the drain would be laid on the same level as that which was ascertained to be the level of the inundated line, and a ditch would be dug both for entry and escape thus :—

DIAGRAM 22.



A being the masonry under channel, round which, during its construction, the water-course might be turned.

It must however be recollected that unless works of this sort are annually cleared out, and choking up prevented, they might just as well never have been built at all.

Bridges.

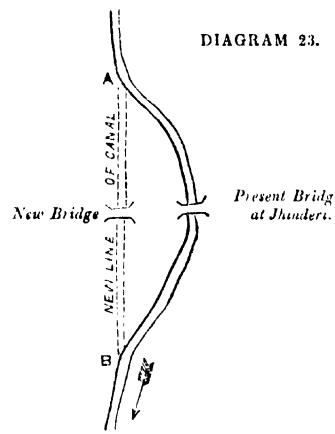
285. In paras. 151, 162, and 169, I have drawn attention to alterations required in bridges for the accommodation of boats

and rafts—in addition to these I should recommend that four new bridges be built at the following places :—

Unutmow Ghat, not immediately required.
Adureespoor, } immediately.
Kyampoor, and Bhetah, }

In building or re-constructing works of this sort between Balpoor and Bynswal, the numerous twists and turns taken by the course of the Canal may be taken advantage of, and the work be constructed without any interference from the Canal water, this method would lead to improvement in straightening the line, a circumstance however that must be taken into consideration when laying down the levels of the flooring of the different works. The position of the Jhinderi Bridge is a case in point, thus :—

DIAGRAM 23.



The new bridge might be built, and the new Canal cut to it, without stopping or interfering with the Canal supply—opportunity might be taken when the Canal was closed for repair or any other necessary purposes, to complete the mouth and escape at *A*

and *B*, and when the Canal was re-opened, the stream would take to its new line, the old bridge would be removed, and the ramps completed.

286. Immediately south of Bahmunmajra there is a very abrupt and awkward twist which I have always intended to dispose of, and had at one time laid down a line straight across the bend, with the intention of excavating the channel on this new course; but I must again repeat that this straightening of direction must be done with due respect to the re-modelled slope of the Canal, and to secure this I would recommend that the line of Canal from the sill of the Balpoor Falls to the flooring of the Kandla Bridge be re-levelled, and the measurements of distance accurately taken, for the permanent line upon which the Canal will run when the twists above referred to are cut off—by establishing bench marks at every bridge and every masonry building on the line, the rise or depression of the floorings of each work may easily be calculated. It does not appear to me to be at all necessary to re-construct bridges precisely on the spot upon which they were originally built, unless there is some peculiar object in so doing,—such as avoiding any interference with the alignment of a high road, or to prevent injury to property.

Chokies.

287. At each of the Falls and Locks, second class Chokies will be required hereafter—these, however, can be built as opportunities offer, the different positions at which these buildings will be required, have been explained in the body of this Memoir.*

* That there may be no misconception as to the quality of the material used in buildings of this description, I may here note that the Chokies are invariably constructed with bricks that are unfit to be used on other works, unless no refuse material of the sort exists, in which case the best sort of brick is used; as a general rule, however, the refuse material is devoted to Choki buildings.

Irrigation Outlets for Rajbuhas.

288. Masonry heads are required for the following Rajbuhas:

Kirthal, west bank.
Loan, west ditto.
Hussoda, east ditto.
Ludwarri, west ditto.

I do not recommend the construction of any more minor irrigation dram heads. The Zumeendars who at present draw their supply from temporary openings cut through the banks, must be persuaded to enter into the Rajbuha system—and the sooner this can be done the sooner will the embankments be restored to order—on the west bank, upon which carriages do not pass, and which has not been maintained as a road, the state of many of these Zumeendars' outlets is very bad, and requires modification.

Kukripoor Drainage.

289. The arrangement suggested in paras. 177 and 178 for the Kukrupoor drainage, may be referred to as worthy of after consideration.

Bricks.

290. Brick earth is found universally on the whole tract through which this Canal passes: I have never been successful with kilns or clamps made in the European fashion, and have therefore used the common native kiln, the size of brick used is 12 × 6 × 2 inches—and their average cost per lakh, including loss, waste, carriage, &c. is barely covered by 500 Rupees.

Kunkur.

291. Kunkur is found in considerable quantities at the head of the Pandhoi Nulla; and near Suharunpoor, it is found in large

masses, and is conveniently situated to the Falls between Ghoonna and Balpoor.

River Stone.

292. River stone (or boulders) is brought from the bed of the Poodhi Jumna, it varies in rate agreeably to the distance to which it is carted, the price per 100 maunds is from 3 rupees 8 annas to 7 rupees. River stone is used at the tails of all the works as far south as Ghoonna.

Delhi Rock.

293. There is a great quantity of the Delhi quartzose sandstone squared into blocks lying about Looni and Ramp, but the people object to its being removed—irregular masses of this rock however are brought from Delhi and carted to the Falls south of Surrowli, at the rate of 5 rupees per 100 maunds. Enormous masses were used by me for strengthening the tail of the Schmpoor Mills, taken (by blasting) from an outlying rock situated on the left bank of the Jumna.[*]

294. The Delhi rock passes from a purely crystalline into a perfectly friable sandstone. The former, in many cases, being pure quartz, and the latter being a sandstone, consisting of small angular fragments of quartz, agglutinated by either an argillaceous or ferruginous cement—when the latter is the case, this sandstone, which is locally called "Bujree," becomes an admirable ingredient for mixing with Hursroo lime for building in water, used in one part of lime to two of the "Bujree." It has been used by me in

* Where stone or kunkur is not procurable, a very efficient substitute may be obtained by building blocks of brick masonry, and leaving them on the works ready for use. I have generally built these blocks of the following dimensions $1' \times 1\frac{1}{2} \times 2$ feet.—and when perfectly indurated, they answer the purposes of stone or kunkur very well. In laying down floorings of Drain channels, where bricks are abundant, I have also used blocks of this description with great advantage.

all the works in the South Division, and is to be recommended—it has also been successfully used on the outer coating of walls, laid on with a float, but for this purpose the light coloured Bujree is to be preferred. The harder and crystalline variety of the Delhi rock comes into many useful purposes, stones for grinding cement, pivot blocks for lock-gates, rollers, &c., &c. The brackets for eaves of buildings made of this species of rock and used largely in old Delhi throughout the period when the Pathan Dynasty reigned, have been brought into common use on the Doab Canal works, where pivots, &c., for lock-gates were required.

Stone Lime.

295. From the Canal head as far south as Balpoor the lime that is used is of a very superior quality, it is made from boulders of lime rock picked from the bed of the Jumna, or from the rivers in the Deyra Dhoon—it is used in the works mixed with soorkhi or pounded brick, in a proportion of one part of the former to two of the latter—where cement mills are not available the proportion of the soorkhi has been sometimes reduced to one and a half.

Hursroo Lime.

296. At the southern parts of the Canal the Hursroo lime is used in the same way and in the same proportion as the stone lime in the northern district. The material itself comes from the village of Hursroo, in the Goorgaon District, about 26 miles southwest of Delhi—it is a fat, indurated and compact marle, containing recent fresh-water shells; it is excavated from low land, in a position very similar to that of the kunkur deposits in the Doab—it is delivered in Delhi in its unburnt state at from 12 to 15 rupees per 100 maunds, and its cost on the works when received from the kilns may be from 25 to 35 per 100 maunds.

Jussooe Lime.

297. In the central districts of the Canal there are numerous places at which kunkur lime is made, but that one most to be recommended is Jussooe, a village situated on the right bank of the Hindun River and 10½ miles due east of Bynswal. This is what is called by the natives an earth lime, that is to say, it is marle, found in a horizontal stratum, to all appearance consisting of an unctuous white earth—this earth is dug out and made into balls which are placed in the sun to dry, after which the balls are burned in the kiln in the usual way. This lime is exceedingly light colored and might be taken for the darker varieties of stone-lime —it is delivered at Bynswal and its neighbourhood at 12 rupees per 100 maunds. The Jussooe lime has a high name with the natives of this part of the Doab, and its use is not merely confined to the immediate neighbourhood of the village, but it is extended to Suharunpoor, and other large towns.

Teekrole Kunkur Lime.

298. I will only advert to one more locality from which lime has been taken, and I do this from the circumstance of the lime in question being invariably used by the Natives, without being mixed with any other ingredient; this lime which is made from a kunkur is brought from the village of Teekrole, 2½ miles S. S. W. of Abba —it is delivered at the Canal works in the neighbourhood, at from 7 to 9 rupees per 100 maunds. The kunkur from which it is made is impure although prolific in the remains of fresh-water shells—and the lime as produced from the kiln, in as far as appearance goes, has nothing to recommend it—the Natives, however, consider it to be a good cement, when used without any admixture of soorkhi or other material. The bridge at Rampoor (with the exception of the arch in which stone lime was used) is built entirely with brick and Teekrole lime as recommended by

the Natives, unmixed with soorkhi—as this bridge will, when the Rampoor Falls are under construction, be removed, it will be interesting to examine the masonry and report on the qualifications of the Teekrole lime.

Suggesting the inexpediency of mixing Soorkhi, &c., with the common Kunkur Limes.

299. With exception to the very superior descriptions of marle, to those I mean in which the carbonate of lime largely preponderates, I am convinced that in the Department of Public Works the mixture of soorkhi with marle and kunkur lime is a mistake. The common marles and kunkurs when taken out of a kiln consist in their own parts of the natural ingredients for a cement: in most instances they will be found to consist of a large proportion of argillaceous and other matter combined with the carbonate of lime; if this is the case, it is evident that the effect of any further admixture of soorkhi or sand must be injurious.

P. T. CAUTLEY, *Capt.*,

February 12th, 1845. *Supdt. Canals, Doab, &c.*

APPENDIX A.

REPORT ON THE LEVELS OF THE DOAB CANAL.

From Capt. P. T. Cautley, Officiating Superintendent Canals, Delhi Territory. To Capt. Edward Sanders, Secretary Military Board.

Doab Canal Office 1st April, 1837.

PREVIOUSLY to describing the method proposed for re-modelling the levels of the Doab Canal bed, it may be better to give as concise a sketch as possible of the general aspect of the section upon which this work has been executed.

2. In looking at the Map and direction of the Jumna from the point where it leaves the Hills to Delhi, and observing the position of the Delhi and Doab Canals with their sources opposite to each other, their lines running parallel, and their escape or tail water joining the parent stream at points also opposite, an indifferent observer would naturally consider that under such coincident circumstances any difficulties would be common to both, and that the works required for the maintenance of one Canal would (supposing their capacities to be the same,) be similar to those of the other.

Levels of the Delhi & Doab Canal compared, with the reasons for the demand of such extensive works on the latter.

3. With regard to the centre and southern regions the levels of each Canal correspond in a great measure; the step which occurs into the Khadir near Surrowli on the Doab Canal, and which

is passed by a succession of falls and lockage, is on the Delhi Canal maintained on the high level by crossing a hollow at the Poolchadur Aqueduct: by retaining this high level into Delhi, the city is amply supplied with water, and the rapid descent into the Jumna takes place almost immediately at the end, the greater part of the tail water passing through and turning flour mills, and the whole escaping over paved and well protected channels into the river.

4. It is in the northern region in which we observe the greatest difference; on the west of the Jumna the Canal passes over wide and open beds of shingle, upon which the stream is able to exhaust itself. These shingle tracts extend as far south as the Dam at Dadoopoor, from whence the Canal passes off in its old and tortuous channel; on the Doab Canal on the contrary the line of Canal takes an easterly direction: branching off from the old stream of the Jumna at Nyashur and deserting the shingle almost immediately afterwards, takes its course over the high lands of the country, with a similar declivity; therefore on both lines the great step is passed, in the Delhi Canal over a succession of wide beds of shingle with considerable tortuosity of channel; whereas in the Doab Canal the small space occupied by shingle is chiefly passed by an excavated passage, on every superficial inch of which attrition is in constant progress; in advance of this shingle the Doab Canal proceeds on straight lines over alluvial tracts more or less sandy—inadequate in themselves to withstand a current of such magnitude.

5. The extent of the shingle beds on the west of the Jumna, therefore points out the comparatively easy way in which this step of country is passed on the Delhi Canal, and explains at once the absence of any necessity for artificial descents for the water; in opposition to the absolute necessity for such works on the Doab Canal, where the objects common to both has to be accomplished under such different circumstances,

Direction and position of the Doab Canal with reference to the country through which it runs, including the distribution of the fall throughout its course and probable reasons of the Canal never having been used by its original projectors.

6. On leaving the Boodhi Jumna (an old branch which was formerly the main channel of the river,) the Doab Canal at the village of Nyashur takes a south-easterly direction, keeping as near the hills as the levels would permit, to the Muskurra river and the village of Kulsea: on this line the drainage of the hills and forests is cut at right angles, and independently of the Muskurra river, the Canal is crossed by the Raipoor Nulla, the Jatonwala Rao and the Nogong Rao, all of which, but the latter especially, although usually dry, carry large volumes of water during the freshes in the rainy months; from the position of the dams and masonry works on these rivers relatively to their distance from the hills, it may be supposed that the slope of their beds at the points of contact is great. The difficulties consequent on the construction and maintenance of dams and checks to large bodies of water passing on rapid descents over sandy soil, have shewn themselves throughout all our operations, exhibited in a system of retrogression of level upon the tails of the dams. The steps or abrupt descents caused by this evil have been met by the application of weirs or slopes of frame boxes filled with stone, which as far as they have gone have been successful.

7. From the village of Kulsea the general direction of the Canal may be described as nearly north and south to the village of Lowalpoor, in the Meerut District, it then obliques off to the west towards Deola from whence it continues in a southerly direction until it reaches the Jumna opposite Delhi.

8. The line of Canal on leaving the high ground of Suharunpoor runs precisely on the summit of the ridge or high land, which separates the Hindun river from the Jumna, its position enables the cultivators to irrigate on the right and left with every facility, with a slope more or less gradual from the waters of the Canal to the valleys of the abovementioned rivers. The levels are admira-

bly adapted to the purposes for which the Canal was intended, and as the line of the present work is that of the ancient Canal, one is struck with the skill of the Engineer who without the aid of the instruments which assist him of the present day, could lay out and plan a work of such ingenuity.

9. The total fall from the old or Fyzabad Head to the Jumna opposite Delhi is 421·08 feet agreeably to my own levels, the total distance being 134·06 miles, giving an average fall per mile of 3·14 feet.

An average of this sort however, is by no means explanatory, in consequence of the unequal distribution of the fall; for instance, from the head to Manukmow opposite Suharunpoor, that is to say, on the first 28½ miles the fall is 186·37 feet, a total which very nearly absorbs half of the entire fall of the Canal: from Surrowli again to the Jumna, on a line of upwards of 11 miles, there is a fall of 45·6 feet.

10. The distribution of the level therefore will be as follows:

	Miles	Ft.	Yds.	Feet.
From the Canal Head to Manukmow,	28	5	117	=186·37
„ Manukmow to Surrowli, ..	94	2	141	=189·11
„ Surrowli to Delhi, ...	11	0	81⅓	= 45·6
Total distance and fall,	134	0	119⅓	=421·08

In other words, from the head to Suharunpoor and from Surrowli into the Khadir of the Jumna, there are two steps of descent; the intermediate line running as will be hereafter shewn on a very general level of about 20 inches per mile. It may be doubtful how in the absence of all works on the ancient line of Canal, especially on that north of Kulsea, the Canal was ever maintained by its original projectors as a running stream. Tradition only bears it out as a very small body of water which ran for one season, until the period of Zabitha Khan's repair, when

the town of Behut was put in jeopardy by a heavy flood which did considerable damage, and of which the marks are now apparent in the hollow near Behut, called the Behut Khala, east of and near the point where the Belka Falls are now constructed, and between the Nogong and Muskurra rivers; the distance between these two rivers is only (taking all the tortuosities of the ancient channel) about 3 miles, and the fall is equal to 27 feet, the soil consisting of river sand; it is evident that no body of water could long run without forming a cut or ravine which would have brought the whole of the Nogong rain supply into the bed of the Muskurra, and this (from the excessive descent into the latter) must have remained permanent; it is therefore to be concluded that the Doab Canal was never used as a line of irrigation in its full extent, but that it was a work in all probability either constructed by Alli Murdan Khan himself, or by some cotemporary who, seeing the success of the operations upon Feroze's old lines of works, projected a Canal parallel to them in the Doab. The tail of the old Doab Canal terminated in an artificial tank or lake surrounded by ancient buildings opposite Delhi, of the period alluded to the Canal probably ran during one dry season, and was given up from the difficulties encountered in managing the mountain torrents, north of the town of Suharunpoor.

11. On my receiving charge of the Doab Canal on the 1st of January 1830, the excavation and most of the works were completed; it was opened on the 3rd of that month in the absence of the Superintendent, Colonel Robert Smith, C.B., of the Engineers, the state of whose health had made an early departure to Calcutta of imperative necessity; the water rejoined the Jumna on the 14th with a steady and uninterrupted flow. The bridges were designed with waterway counter-arched and curtained, the curtain

Opening of the Doab Canal, with the after disarrangement of the levels of the bed. Progressive adoption of works for their re-establishment. Deposit of silt pointed out and explained. Diminution in the influx of silt since the masonry falls in the northern regions have been established.

walls being sunk to a moderate depth only on all the line south of Suharunpoor where the soil was good; at the bridges north of this point and in the sandy districts, the curtain was in some instances as deep as 14½ feet, at others where this could not be managed from the interference of spring water, wells were adopted, but the bridges were protected as far as possible by flush curtain foundations.

12. The levels of excavation were guided in a great measure by the country's surface with reference to irrigation, so that when I refer you to the black line on the section of the Canal which accompanies this Report, a very tolerable idea of the superficial section of the country may be obtained. By reference to this section it will be observed that the Canal bed consists of a series of alternating levels, a fall of considerable rapidity at one point, is followed by a line of comparatively moderate descent, this is followed by an other rapid, and so on throughout the whole line. About a fortnight after the water had been admitted the evil of this irregularity began to display itself, at the Belka and Ghoonna bridges, as well as at the Selimpoor bridge at the extreme tail, formidable rapids at once established themselves, at Belka the force of the current was beyond all control, and at the Ghoonna and Selimpoor bridges temporary rapids did their duty: it may only be taking up your time to enter into this detail, the whole of which has been previously recorded, but the authority of Government for the construction of works at the above places, was followed by a further authority for the construction of a farther series of falls south of Kulsea, at Nugla, Bobyl and Rundole, to dispose of the great step to Ghoonna, and also for the completion of a set of falls at Sookulpoor, Sikrani, and Jaoli to complete the levels and conquer the descent into the low lands of the Jumna. These works have proved satisfactory, in as far as this line of level has been concerned, and I had hopes that although the intermediate fall was enormous, I might have been able to remedy the evil by strengthening the tails of bridges without having further masonry works.

13. During the period abovementioned when the wear and tear of the Canal bed (extending along the whole line of step from the Head to Ghoomra) was going on, under rapids increasing in power, as they retrograded, and during the time when all the Canal channel in the upper line was getting cleared out of sand, the quantity of silt carried forward was very great, the deposits established themselves partially opposite Suharunpoor, but more especially at four points farther south, viz. north of Bynswal, north of Kandla, south of Kukrupoor, and in the neighbourhood of Lowalpoor; the process has fortunately been so gradual that I have been able by great exertions on the part of the Overseers, and latterly by the consideration of the Military Board in allowing me an Assistant Overseer, to keep the embankments up to the encroaching evil. The process of the deposits will be distinctly recognizable by reference to my line of levels. The silt first takes up its position on the most advanced point, a short way in rear of the head of a rapid, and the deposit continues to form, retrograding, until the bed has gained something like its proper regimen, or in fact obtained an *uniformity of slope on extended lines*. By referring to the sheet of sections, and looking at the line north of Bynswal, &c. &c., the circumstance to which I refer will, I think, be apparent, it is a point to which my attention has been especially directed. For the last six years I have watched the whole process with attention; and in the project for re-modelling the levels which I have the honor of submitting, the observations so obtained have been taken especial advantage of; on my submitting plans and estimates for the Falls south of Kulsea, I particularly adverted to the circumstance of the silt deposits, of their origin, and of the final results that I considered would take place from improvements proposed—it was my conviction that the silt originated from the clearance out, and deepening of the line of Canal upon its whole northern course, but especially at those points between the Nogong and Maskura rivers and south of Kulsea at which the Falls were to be built. I con-

sidered that the portion of sand or silt derived from the Canal water passing over the dry beds of the mountain streams was comparatively of no moment, and that ultimately on the establishment of a proper regimen in the flow of the Canal water, we should gradually rid ourselves of the silt; this was a point which was discussed at some length, and doubted in Calcutta—the minutes of two Members of the Military Board at that time, being opposed to the principle. The results have, however, most undoubtedly borne me out in my opinion, the influx of sand and silt is so much lessened, that all the deposits opposite Suharunpoor, (that is to say, the most northerly one on the whole line,) are now carried forward, and in the place of 2½ feet of silt on the floorings of the Manukmow, Mekchupper and Adumpoor Bridges, the original rapids are acting with their former vigour. To the head of the Ghoonna Falls, the water runs as clear as it could be expected to do, under the rush and removal of soil that takes place at the immediate tails of Falls, (and on the line south of Belka; for which plans and estimates for an additional Fall have been submitted); in short, that the influx of sand *now* is insufficient to maintain the deposits; that those most northerly have all been carried forward; that the deposits generally on the Canal are undergoing a similar advanced movement—and that the time has now arrived, when an extension of Falls, and a general regulation of the line of levels, may be put forward with advantage to the interests of the Canal.

Preliminary remarks on the proposed works, for remedying the irregularity of the existing levels.

14. In obedience to the instructions conveyed in your letter of the 14th February 1836, the plans and estimates have been formed under the two considerations of irrigation and navigation; No. 1 Estimate, shewing the amount of works, required for simply completing the levels so as to admit of security to irrigation; and No. 2, that for a navigable line, with the exception of a decrease to the Fall in the latter by the adoption of two additional Falls of 4 feet each, the works of the former are

similar to those of the line for navigation, the additional length of chamber might be added hereafter if necessary. In considering either or both of these arrangements the following preliminary observations will apply.

15. In Canals, in a tropical climate, where vegetation increases rapidly, and where such an increase of vegetation in the form of reeds, rushes, and water plants, is of the most serious inconvenience, it is necessary to provide a run of water that will be sufficient to prevent the growth of plants, and insufficient to act in an injurious way to the bed and sides of the channel; a fall less than 12 inches per mile will not prevent the growth of water plants; that which has been used by me with the greatest success is one inch per hundred yards or 17·6 inches per mile—in a hard soil this may be considered the minimum and 24 inches the maximum, with such a fall no annoyance from weeds need be anticipated, In my plans the existing bridges have been taken into consideration with a view of applying the re-modelled line as closely as circumstances would permit to their floorings, and to economize as much as possible the works upon which the present alteration in the level will act. This has partly been the cause of 24 inches per mile level having been extended to such a distance, the maximum descent might perhaps with advantage be avoided as in the No. 2 Estimate, although considering the tortuosities in the lower part of the line upon which this will run, I do not consider that any ill effects will arise from it; more especially as it will be seen that the tails of the 4 feet Falls are provided with an advanced line of piling in addition to the terrace or box flooring. The line of levels has been considered in two portions, the first from the Canal head to the Kandla Bridge flooring; and the second from the Kandla Bridge flooring to Selimpoor and the Jumna; the first portion is that only upon which I intend to offer any proposal for masonry works; the fall from the Boodhi Jumna to Allumpoor is immense, but as it traverses shingle on the greater part upon which the

rapid descent takes place, and as there can be no demand within any reasonable period for the passage of any thing but rafts, which in moving from the upper to the lower line would not be incommoded by such rapids, I shall consider this upper portion of the Canal as in such a state that the levels may be maintained by ordinary repair with the use of frame boxes; on this point Colonel Colvin has also expressed a similar opinion, as in the event of the Canal becoming a navigable channel for boats, the country opposite Gundewur and Allumpoor would in all probability be the most northerly point from which grain or merchandize would be loaded: with regard to the second portion, or that from Kandla to the Jumna, the lowest half, including the step into the low lands before alluded to, has already been rectified by falls and locks, the space only between Kandla and the head of the most northern Fall at Sookulpoor is to be considered,—on this line the existing fall is as nearly as possible 20 inches per mile, a good and efficient slope, requiring no reduction; the present inconveniences arise from the irregularity of level formerly referred to (para. 11), this will lead to the protection of the tails of bridges (the Nalla bridge at this moment has a severe rapid under it), and as at Romalla, Bural, &c. a rise to the banks and bridges. The supply of water on this portion of the Canal does not however offer such serious impediments to counteracting its effects, as it does in the northern districts, the stream here is more under control, especially since the construction of the escape into the Shamli Nulla at Kheeri, and any deposits of sediment will be sufficiently gradual to admit of a gradual repair, and this I would recommend under Estimate No. 3 in preference to putting the work at once into execution.

On the Doab Canal as a line of irrigation, specification of works required, slopes of re-modelled bed.

16. From the Boodhi Jumna Dam at Nyashur to the Head of the Belka Falls and Regulator, masonry works will not, as I before remarked, be required; the rapids which exist may be maintained by frame box-work, and in my annual estimate for ordinary

repairs the maintenance of this line will be especially adverted to. From the Belka Falls to the head of the Surkurri Falls, a descent will be provided of 17·6 inches per mile, or thereabouts, to effect which a new set of Falls of 7 feet descent will be required between the Belka Falls and the Muskurra river: plans and estimates of which have been already submitted to the Military Board. From the Surkurri Falls to the Kheera Gudai Falls, the soil being of a tenacious quality, kunkur and clay, with the most southerly half of the line tortuous and irregular, a descent will be provided of 24 inches per mile; on this line I propose the construction of a series of half falls of 48 inches each, agreeably to the plan accompanying, at the following places :—

1st.	Fall	North of the Surkurri	Bridge.
2nd.	do.	Halalpoor	do.
3rd.	do.	Mekchupper	do.
4th.	do.	Reeree	do.
5th.	do.	Balpoor	do.
6th.	do.	Rampoor	do.
7th.	do.	Kullurpoor	do.
8th.	do.	Poojna	do.
9th.	do.	Kheera Gudai	do.

A total of nine Falls—they will be constructed agreeably to the plan accompanying, (with the exception of those at Surkurri which will require well foundations and the full length of chamber,) with a masonry tail of 40 feet in length from the ogee, and with a 25 feet terrace of boxes loaded with river stone or kunkur, whichever may be cheapest, and the most readily procurable; these tails or terraces will have a slope of 12 inches, and a line of piles driven with their heads on a level with the rear line, at a distance of 25 feet in advance, by which means wear and tear will be interrupted in any retrograde, and the means provided for filling the hole made by the waters rush with heavy material. From the Kheera Gudai Falls to the Kandla Bridge, the descent will be equal to 20 inches per mile, to effect which the floorings of four bridges opposite Shamli will be lowered, and the water will be allowed to clear

away (a work which has long been in progress, but only interrupted by the bridge floorings much to their detriment,) the bank or bar, as will be seen by reference to the section; as this bar has been the cause of the excess of deposits north of Bynswal, with a corresponding expense and anxiety in the management of the Canal at that point, under such a rapidly rising surface, its removal is a point of the most immediate importance, and the alterations to the bridges with reference to getting rid of such an incumbrance was commenced upon, as an ordinary repair, in the early part of the present cold season; it will, I hope, be completed and ready to be put in operation by the commencement of the rains. On the line north of Bynswal, the arches of the following bridges will have to be raised:—

1st. Nynpoor Bridge.
2nd. Tirwa ditto.
3rd. Jhinderri ditto.

This, with the completion of the banks, will constitute the remodelling of the line from the Head to Kandla.*

17. From Kandla as I have before noted, to the head of the Sookulpoor Falls, (the line south of these Falls having been regulated,) the declivity of bed is as nearly as possible 20 inches per mile, the difficulties under which it now labours arising from the irregularity of distribution, and not from any excess of slope. I consider that it would be useless to reduce the present fall by the construction of masonry works, and it would be most injurious to the irrigation, now so rapidly advancing, to attempt by altering the Canal bed to reduce the height of surface water. The body of water by the time it reaches Kandla is so much reduced, that it is always under control, deposits that will take place can be met by gradual repairs, and under the diminution of the influx of sand,

* As the re-modelled slopes have been calculated on the supposition, that the whole distance between Abba and Bynswal was in a straight instead of on a tortuous line, it is possible that the Poojna and Kheera Gudai Falls may be dispensed with.

with the action of a current moving on a slope beyond 18 inches, there is no probability, I imagine, of the Canal bed actually assuming the regularity of slope, shewn by my dotted line on the section; the deposits with which we are troubled, consist of soil too light to admit of permanence: the silt deposited at low angles will remain, and it will only be when the deposits come within the action of the higher slopes that they will be pushed forward. I see no necessity whatever for interfering with this line at present, excepting by repairs and improvements at certain points; at Romalla and Bural perhaps a rise in the arches of the bridges may be hereafter required. In my section a dotted line has been drawn to shew the actual slope of 20 inches per mile, but as I have before said, there are sufficient reasons, why silt should never in reality assume such a regularity of level under such a slope; the section will, however, shew to the Board the irregular distribution of the present levels as exhibited by the dotted and the plain lines.

18. The series of descents between the head of the Belka and that of the Sookulpoor Falls will be thus:—

From Belka to Surkurri, ...	17·6	per mile.
„ Surkurri to Kheera, ...	24	ditto.
„ Kheera to Sookulpoor, ...	20	ditto.

On the adoption of three chambers to the Falls instead of two—inconveniences of two chambers at Belka Falls.

19. In the plan proposed for the new Falls, I have been led from observations made on those that have been in use, to give an increased width to the chambers, so that the water in its passage over the masonry may not be contracted, and that means may be provided for the repair of the floorings, when by accident or otherwise such a repair is required. To a person who had never seen the Falls at Belka for instance, no description would probably come up to the rush and fury of the torrent as it passes over the second descent; I confess my own surprize at the tenacity of masonry in resisting such an opposing force: the water has now been in constant progress over the Belka

Falls for six years, with no further injury than a slight damage to a flooring from a raft laden with stone having passed down by accident, and to a slight settlement of the left tail wing revetment, which has not arisen from any weakness in the masonry, but from the clearance out of the soil in advance of the work, and the foundations suffering under a head pressure of more than 15 feet, which has been gradually forcing the substratum from underneath the floorings;* evils of this sort will be prevented and remedied by the construction to the south of the Behut Falls, these will hold up a back-water and not admit of the stream running off the tail on a free slope. Logs of wood, trees, and articles of that description are very injurious to the floorings of these Falls, and it is impossible to prevent their admission into the Canal. The plan now proposed of a centre opening of 20 feet and two side openings of 15 feet each, with division walls, will provide the means of efficient repair under accidents of this nature, and a chamber can be at any time laid dry without interruption to the flow of water. In the existing Falls at Belka, Nugla, Bobyl, Rundole, and Ghoonna, an accident is of the most serious importance from the excessive difficulty in repair: and with regard to the Belka Falls, this is a point which has so forced itself on my notice within the last year, that with the permission of the Board I would suggest the advantage of applying the additional 15 feet chamber, a work which might be executed after the Behut Falls were completed.

The Doab Canal as a navigable line.

20. In considering the term navigable Canal in its accepted sense, viz. a navigable channel with no current to impede or delay the passage of craft, and with the levels completed in a series of still or nearly still reservoirs, the Doab Canal can hold no claim to any consid-

* The action here referred to ultimately led to the giving way of the lower chambers. The substitution of an inclined plane for the original ogee, and the construction of the Behut Falls, which have thrown back-water upon those at Belka, have rendered the latter work quite secure.

eration; nor would any moderate project for such a re-modelling be either consistent with the objects in view, nor would it be beneficial to the cultivators in the point of irrigation.

21. There is a medium, however, in which both objects may be gained, we may keep the flow of water under the proposed regimen, so as to counteract the evil to be expected from weeds, and at the same time by converting the present Falls into locks, provide the means for every species of navigation that we can possibly expect in this remote position for a number of years.

22. To this point I have always had my attention fixed—all the Masonry Falls that have been constructed, are in a state to provide lockage by the mere application of gates, and the fixture of the supports for the collars, with the exception of the Ghoonna Falls, in which a trifling addition would be required in fixing the stones for the lower gate pivots. In my plan proposed for irrigation in the last section, this system has still been continued, and the lock chambers are left incomplete simply in the advanced half of the masonry.

23. Keeping therefore to the present system as much as possible, I have appended an Estimate regarding the Doab Canal, as a navigable line, under the following modifications, considering that rafts of timber of different descriptions are the only species of articles requiring conveyance on the upper line from the head to the Belka Falls—I would, as in the Canal for irrigation, have no masonry works north of that work. The lockage would commence at the Belka Falls and would be continued throughout the line to the Sookulpoor Falls: these Falls with the southerly ones of Sikrani and Jaoli are already locked; Selimpoor has also a chamber ready to receive gates if necessary, although were the descent into the Jumna from Selimpoor requisite, as it would be under a regular system of navigation, a second chamber would be required, as the present one is allied to the Mills in such a way that the passage of boats would be the source of constant interrup-

tion to the millers. During the rainy months when the Mills are not running, in consequence of the height of back-water from the Jumna, no lockage would be required, as the Jumna at this period affects the surface level of the Canal as far back as the Jaoli lock chamber, up to which I am in the constant habit of boating articles from Delhi during the rains.

24. I would reduce the 24 inches per mile line of levels to one of 20 inches, by two additional 4 feet Falls, this with the mere completion of the chambers to their full length, would constitute my project for this modified line of navigation: the Estimate for which, is that numbered 3. I would not for a moment hold out to the Military Board any hope of an immediate demand for the Doab Canal as a navigable line, but that it will be so at some future time I have no doubt of. The Board will be best able to judge whether it would be advisable by recommending No. 3 Estimate, to complete these works at once, whilst the Canal water is turned round the works; and with an uniformity of design; or whether it will be better to keep the navigation principle in abeyance.

25. The Estimates which accompany this, will, I trust, be satisfactory in shewing the amount which will be probably expended on either side, whether that for irrigation or for navigation is desired. The difference is Company's Rupees 51,313-6-6—I would submit the advantages of the latter, as I consider that as lockage will assuredly be called for hereafter, the point can only hinge in an economical point of view on the interest of the excess of outlay —that is to say, on the interest of the above sum of 51,313-6-6, and I think that in descending into details, it will be found that the contingencies depending on the after adoption, and after completion of the chamber, will more than counterbalance any economy of this sort. The contingencies to which I allude, are:—

1st. A necessity for turning the Canal water, digging cuts, forming bunds, &c, &c.

2nd. Taking up all the advanced terrace and piling; the stone of the former will be saved, but the whole of the piling will be lost.

3rd. The usual contingencies attached to setting works of any description in progress, when such works especially are at a distance from towns and workpeople.

26. In conclusion and with reference to the subject of navigation; as the Doab Canal runs centrically through this portion of the Doab, connecting itself with the river Jumna at both extremities in an open and passable channel, it will not only be open to rafts, which under a moderate transit duty, would, on many occasions, if not always, prefer this line to that of the main river, but it would lead to cheap means of carriage for all the produce of the countries through which it runs, of the grain and sugar of the Suharumpoor, Mozuffurnuggur and Meerut districts; it would provide a cheap means of carriage for all the Hill produce which would be brought down to Gundewur and Raipoor and boated to Dehli: and as the northern regions from the moisture of the climate are well adapted to the growth of Indigo, although no European speculator has yet put it to the test on a large scale, we should be able to open out a connecting line between the Indigo tracts and the main navigable line of the Jumna.

Conclusion with reference to navigation, and the use that has already been made of the Canal as a line for boats and rafts.

27. In the present state of the Canal, and with all the disadvantages of the bridges north of Bynswal, having their water-ways choked from the rise of the level of the water's surface, I am in the constant habit of floating timber of all descriptions from Suharumpoor to Dehli and other intermediate points; at this period timbers similar to those which are selling in Delhi at 22 rupees each are floated down, including the Canal transit duties, and all other expenses, for rupees, 17-8-0, and other articles are obtained in this way at an equally reduced rate: boats have long been in use on the works for the conveyance of articles of every description,

with a great saving to Government in the cost of materials. Fire-wood, and trees cut down in clearance, are forwarded to Dehli in the Canal boats, and during the last year have made a considerable increase in the return for "Sale of Canal produce." I have lately established two boats for the transport of grain and merchandize from Shamli to Selimpoor, the return for which has been sufficient to make me mention the circumstance, as one likely to be productive of benefit, the passage of these boats has been interrupted by the want of water in the lower part of the Canal, owing to the state of the banks in the centre division; but the success of these two boats under the present disadvantages, leads me to infer that the results will be very satisfactory when the supply of water will admit of an uninterrupted progress. A great desire was manifested by the Shamli traders to enter into this arrangement, and I look forward with a tolerable degree of certainty to the establishment of a regular system of boating between the centre of the Canal and Delhi, this will in due course lead to a communication with the higher points, with Suharunpoor especially: I therefore hope that in taking into consideration the estimates which I have now the honor of submitting, the Military Board will consider that the prospects of the Doab Canal being used for navigation, are by no means hopelessly distant. A part of it has already entered into its initiation, and if the means offered by my No. 2 Estimate are approved of, the prospect of a more extended use of the waters, as the means of carriage, is likely to be more immediately realized.*

(Signed) P. T. CAUTLEY, *Captain*,
Officiating Superintendent Canals,
Delhi Territory and adjoining Districts.

---

* I have not thought it necessary to give copies of either the plans of Falls or the Estimates referred to in this Report, the passing of which through the Press would be a source of delay: this Appendix moreover is especially directed to the elucidation of the original and projected slopes of the Canal bed.

APPENDIX B.

SECTIONS of the **DOAB CANAL** taken at the **BRIDGES** between **BYNSWAL** and the **BALPOOR FALLS** shewing the High Water marks of 1830 and 1834, in elucidation of the Silt deposite and the consequent raising of the Embankments

Fig 1

On the Bynswal Bridge May 27 43.

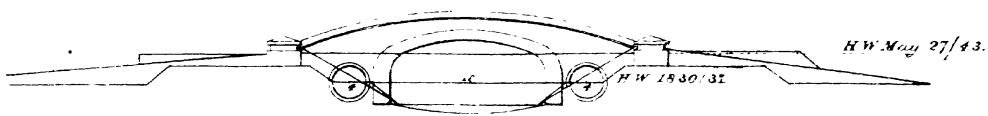


Fig. 2.

On the Shamli Outlet May 27/1843

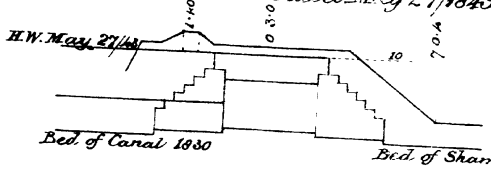


Fig. 3.

1500ft. N. Shamli Outlet E.B. May 27th/1843

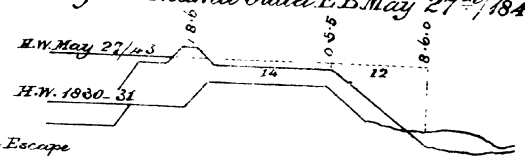


Fig. 4.

At the Jindheri Bridge May 1843.

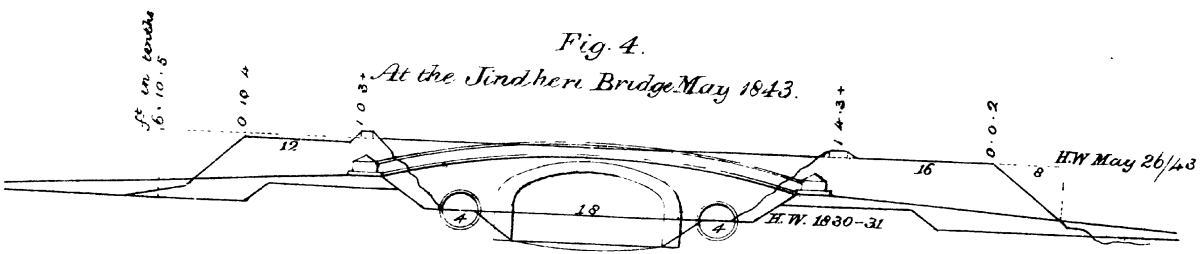


Fig: 5.

At the Thurna Bridge: May 1843.

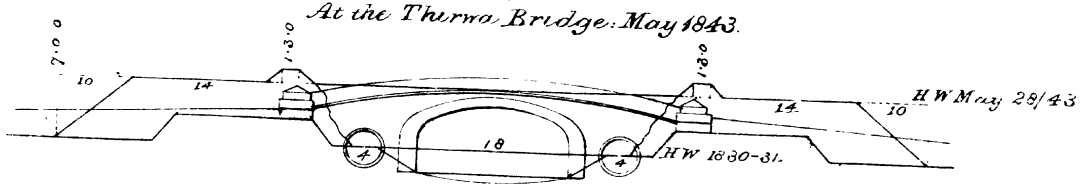


Fig: 6.

At the Kyl Bridge, May/43

Fig. 7

At the Khera Gaddaye Bridge May/43

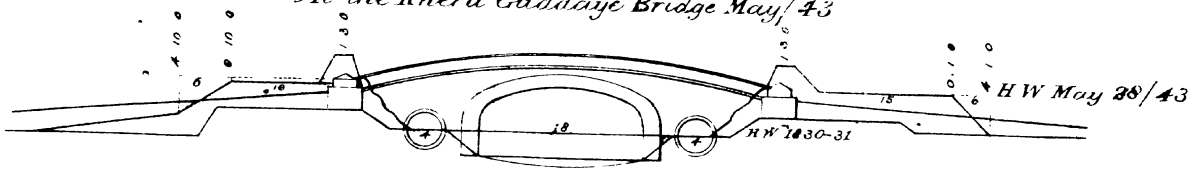


Fig. 8

At the Manichpoor Bridge May 28/43

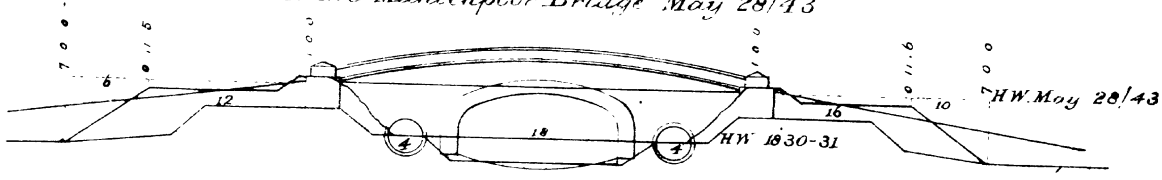


Fig 9

At the Berkhem Bridge May 28/43

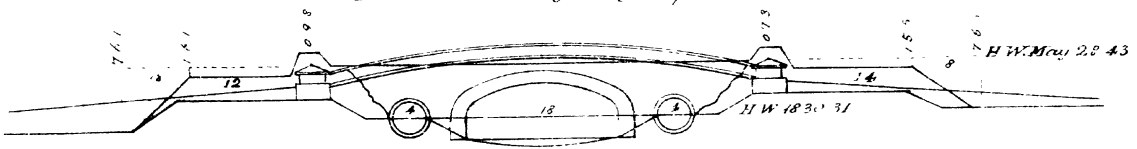


Fig 10

At the Poona Bridge May 29 43

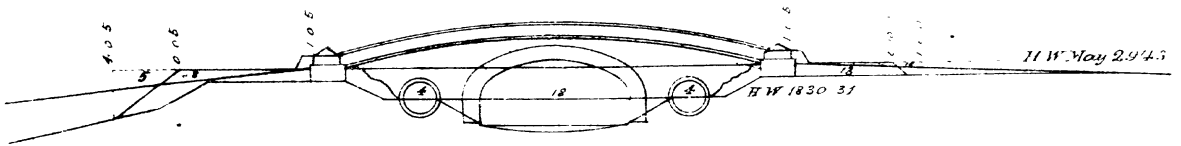


Fig 11.

At the Bursa Bridge May 29 4.3

Built 1835

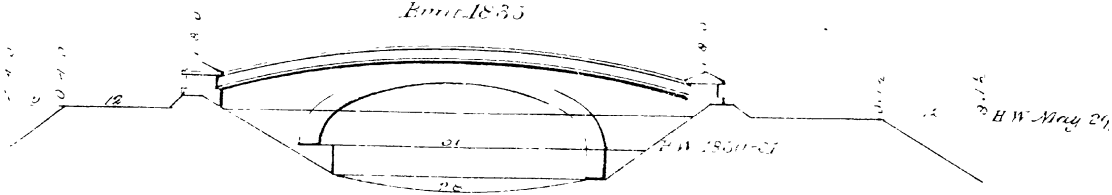


Fig. 12.

At the Bhamanmajra Bridge May 29 43

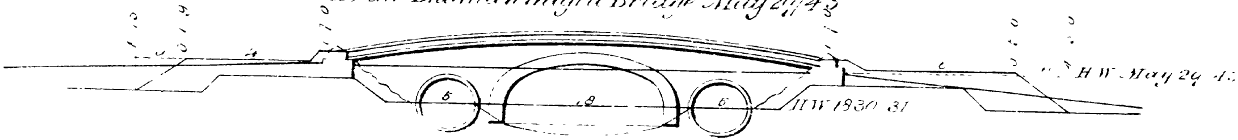


Fig. 13

At the Kinnoor Bridge May 29. 43

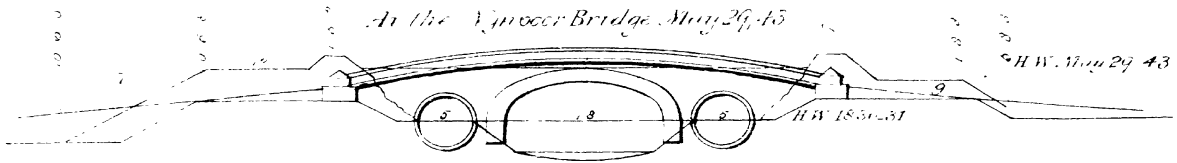


Fig. 14

At the Abba Bridge May 29. 43

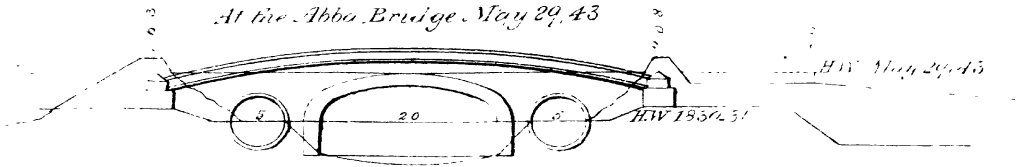


Fig. 15

At the Kallurpoor Bridge May 3043

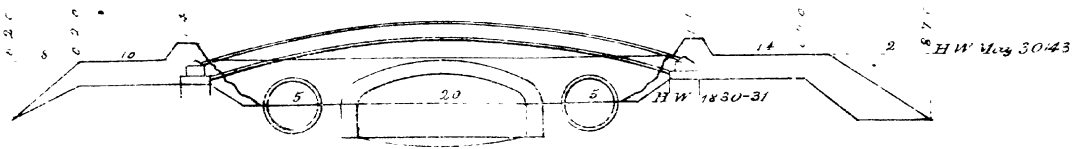
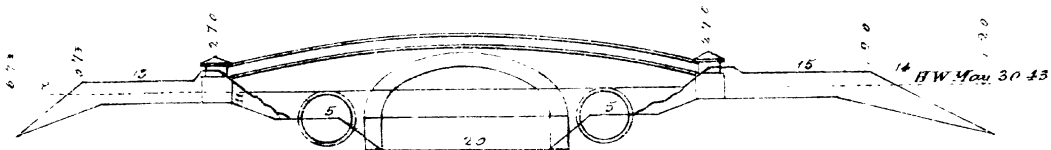


Fig. 16

At the Rampoor Bridge May 30 43



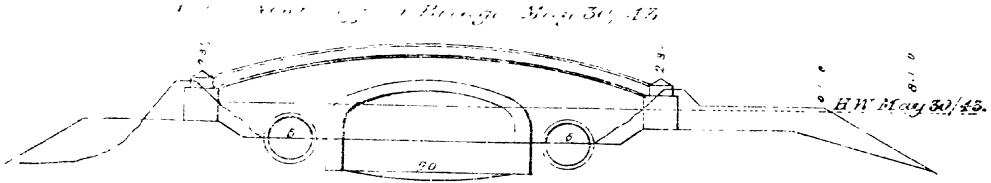
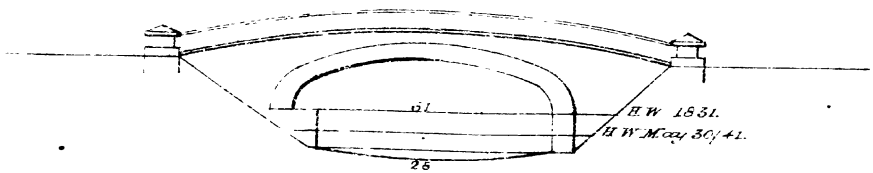
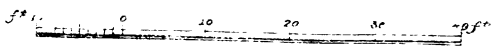


Fig. 18.
At the Nyl's Bridge May 30/43
Built 1836





Scale 20 F. 1 to 1 Inch

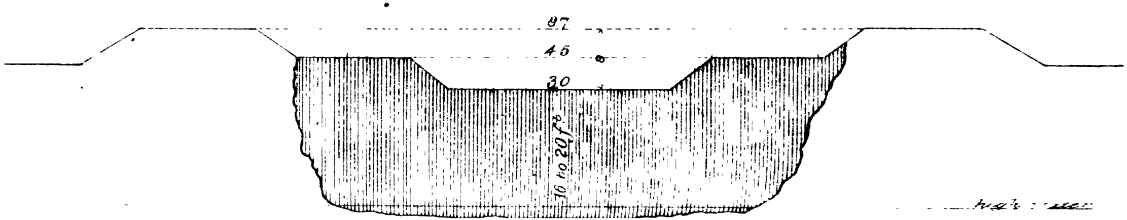
T C PRESS.

SECTION ON THE DOAB CANAL,

Exhibiting the extent of excavation in the Northern Districts caused by the wear and tear of the Current, and the height to which the Embankments have been raised in the Southern Districts to meet the deposits, both of which are shewn by the shaded parts of the Section

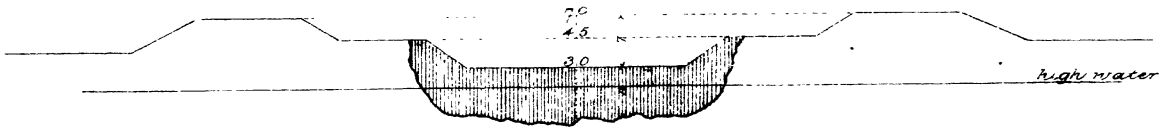
SECTION. 1

From the Nogong Dam to the Muskurra R



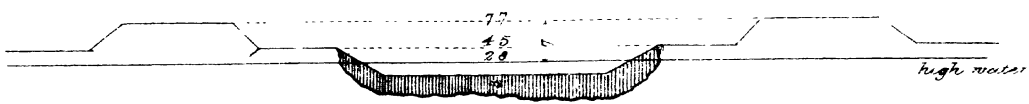
SECTION 2

From the Muskurra R to the N of Surkurra



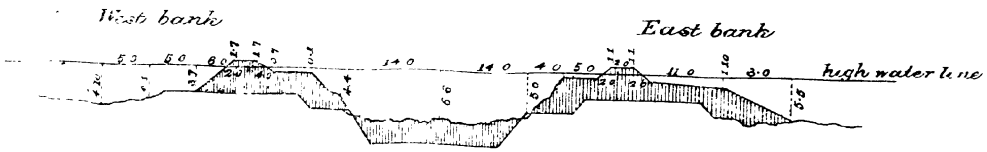
SECTION 3

From N of Surkurra to Nowrungpoor



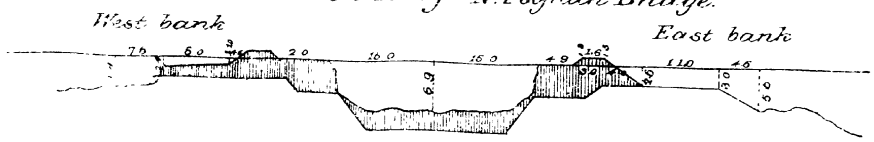
SECTION. 4.

Section 1000 ft S. of Khera Bridge



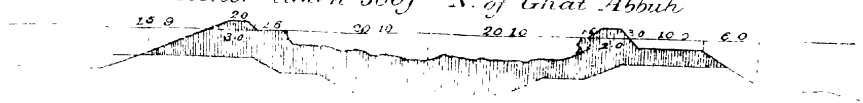
SECTION. 5

Section taken 1000 ft N. Poynuh Bridge.



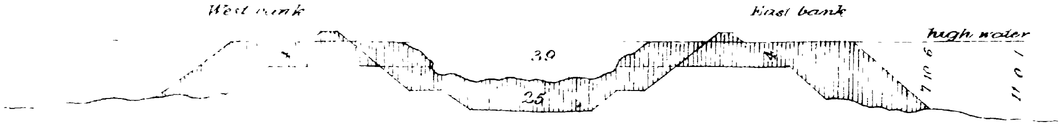
SECTION. 6.

Section taken 900 ft N. of Ghat Abbuh



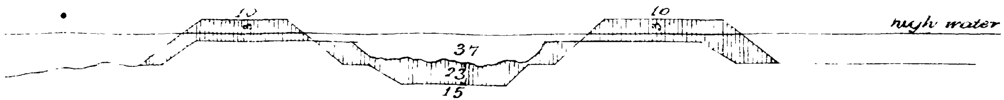
SECTION 7.

South of Kukripoor Bridge



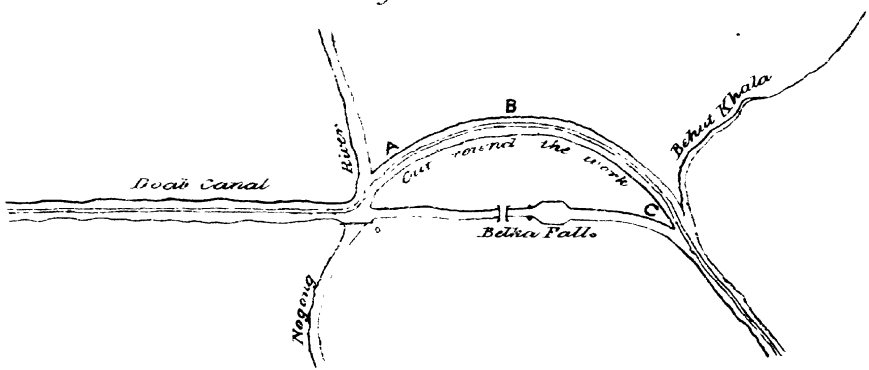
SECTION 8

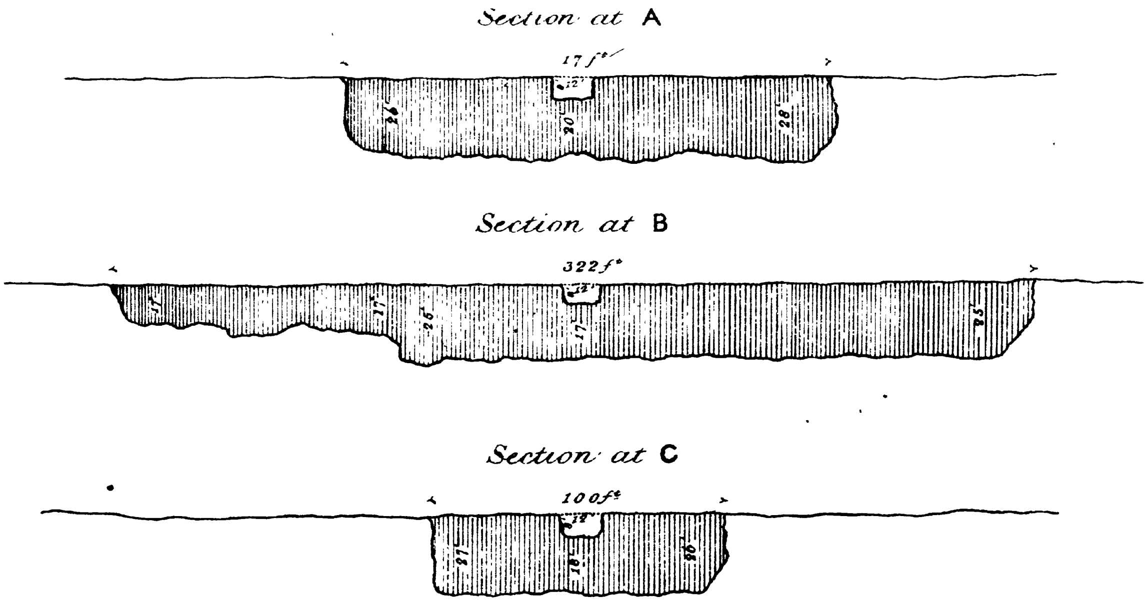
South of Jaah to uckulpoor



SECTIONS ON THE CUT ROUND THE BELKA FALLS.

Total length 4420 ft. or 6 furlongs
153⅓ yards





APPENDIX C.

Abstract of Works constructed upon the Doab Canal under the Superintendence of Captain P. T. Cautley.

Description of Works.	Estimate. Amount.			When Passed.	Bill. Amount.			When Passed.	When commenced.	When completed.	Officer or Overseer in charge of the Works.
Bridge at Mobarukpoor,	935	0	0	15th June '30,	764	4	6	22nd March '33,	31st Jan. '31,	31st Jan. '32,	Serjt. Brew, Overseer.
ditto at Muhrumpoor,	935	0	0	ditto,	764	4	6	ditto.	ditto,	ditto,	
ditto at Baoli, North,	935	0	0	ditto,	864	11	9	27th Feb. '34,	30th June '32,	30th Nov. '32,	
ditto at Bursa,	935	0	0	ditto,	927	9	9	19th May '36,	31st March '35,	31st May '35,	Serjt Petrie, Overseer.
Falls and Regulating Bridge at Belka,	10861	12	1	15th Sept. '30 & 20th Ap. '31	11692	12	5	27th Feb. '34,	30th April '30,	31st July '32,	Serjt. Pigott, ditto.
Additions to Falls, &c. at do.	16908	3	0	16th Oct. '37,	16780	15	11	21st Aug. '38,	30th Sept. '37,	1st May '38,	
Completing Revetments to do. & making Lock Gates,	22229	0	0	13th Nov. '39,	21040	1	7	10th Aug. '43,	31st July '38,	28th Feb. '43,	Ditto the Revetments, Serjt. Brew the wood and iron work.
Falls and Mill at Ghoonna,	7234	14	10	15th Sept. '30,	8795	5	8	27th Feb. '35,	31st Jan. '30,	31st May '34,	Serjt Petrie.
Additions to ditto,	13578	5	3	21st Sept. '38,	10970	12	4	28th June '41,	30th Nov. '38,	30th Nov. '40	Serjt. Pigott.
Additions to Nugla Falls,					9790	14	8	ditto,	ditto,	ditto,	
4 Mills at Selimpoor,	4800	0	0	20th April '31,	4792	15	0	22nd March '33,	28th Feb. '30,	30th April '32,	
Falls & Locks at Sookulpoor,					6719	7	4½	5th Aug. '35,	31st May '31,	28th Feb. '34,	Serjt. Brew.
ditto at Jaoli,					6246	13	9	ditto,	ditto,	30th June '34,	
do. and Bridge at Sikrani,					5242	5	5¼	ditto,	30th April '33,	31st Oct '34,	
Falls and Mill at Nugla,	61767	12	4½	20th Nov. '32,	14947	5	11½	27th Feb. '35,	28th Sept. '32,	30th April '34,	
Falls and Bridge at Bobyl,					12902	7	3¾	ditto,	28th Feb. '33,	ditto,	
Falls at Rundole,					13316	4	9	5th Aug. '35,	31st Jan. '33,	31st Dec. '34,	Serjt. Pigott.
Bridge at Malaheeri,					3273	3	1	7th Dec. '37,	28th Feb. '35,	31st May '37,	
Additions to Bobyl Falls, ditto to Rundole ditto,	12359	13	3	6th Feb. '39,	5743	14	5	14th Sept. '42,	31st Jan. '40,	31st May '41,	
					4434	1	9	ditto,	31st Oct. '40,	30th April '41,	
Kheeri Escape,	Col. Smith's General Estimate for outlets.				2441	12	7	18th Nov. '40,	30th April '38,	30th April '40,	Serjt. Petrie.
Mills at Belka, Nulhera, Chidbunna,	...	...	...	11th Dec. '32,	824	3	10	27th May '34,	30th March '32,	31st Aug. '32,	Mr. Sub-Conductor Brew.
Basement Story of Suharunpoor Mills,	...	...	...	ditto,	1038	4	2	19th May '36,	28th Feb. '30,	31st July '30,	Belka, Serjt. Pigott—others Capt. Cautley.
Bridge at Kundraoli,	1980	9	10	30th Sept. '33,	835	10	8	24th Nov. '35,	31st Jan. '35,	31st March '35,	Capt. Cautley.
ditto at Myhee,					1132	6	2	15th Dec. '36,	29th Feb. '36,	31st April '36,	Serjt. Brew.
New Head at Kharra,	2000	0	0	13th May '34,	2244	5	5	29th Dec. '35,	31st July '34,	31st Jan. '35,	,, Petrie.
Additional Tail to Nogong Dam.	2810	0	0	23rd May '35,	2799	10	0	13th Dec. '36,	31st May '35,	31st May '36,	,, Pigott.
Raising Ramps of Doola and Barote Bridges,	620	0	0	23rd Feb '35,	619	10	7	ditto,	30th April '35,	31st Jan '36,	,, Brew.

Bund and Spur at Kalowala,	2640	0	0	23rd May '35,	879	17	1	28th April '37,	31st May '36,	31st July '36,	
New Tail to Muskurra Dam,	12550	13	4	19th Dec '35,	2168	5	9	7th Dec '37,	31st Dec '36,	30th June '37,	
Additional Flank openings to ditto,	11038	8	9	ditto,	15403	14	10	13th. Dec '36,	31st Oct. '35,	30th June '36,	Serjt. Pigott.
Falls at Behut,	14743	0	9	27th March '37,	7705	8	1	28th Oct. '38,	31st July '36,	30th June '37,	
					22885	15	6	2nd Oct. '41,	31st May '37,	31st March '41,	
ditto at Surkurri,					16535	13	10	22nd Jan. '41	31st Dec. '37,	30th June '40,	Serjt. Wilson, Assist. Overseer.
ditto at Mekchupper,					10523	0	6	26th July '41,	30th June '38,	31st July '41,	Serjt. Petrie.
ditto at Hulalpoor,	47150	10	7	1st Aug. '38,	10201	15	4	ditto,	ditto,	ditto.	
ditto at Reeree,					8333	6	11½	15th Jan. '42,	31st Aug. '38,	31st Aug. '41,	Began by do. completed by Mr. Brew.
ditto at Balpoor,					6762	4	3½	ditto,	31st July '38,	ditto,	
Improving Ramps,	2650	0	0	29th March '37,	2519	1	6	9th May '42,	31st Dec. '36,	31st Jan. '42,	Mr. Sub-Condr Brew.
Nugla Rajbuha,	3000	0	0	14th Oct. '39,	2934	10	8	29th April '42,	30th June '39,	31st May '40,	
Aqueduct, Dumola,	3500	0	0	ditto.	*3500	0	0	26th Jan. '42,	31st Jan. '40,	28th Feb. '41,	Serjt. Pigott.
Outlet at Nowrungpoor,	1800	0	0	20th March '41,	1783	8	3	29th April '42,	31st Dec. '40,	30th Sept. '41,	Kunnya Lal.
Dam at Fyzabad,	13304	0	0	23rd Sept. '41,	13381	3	1	20th July '43,	31st Oct. '41,	30th April '43,	
Tail to Nogong Dam,	18000	0	0	19th April '42,	16486	11	9	20th July '42,	30th Nov. '41,	36th June '42,	Mr. Sub-Condr. Pigott.
ditto ditto,	24000	0	0	24th March '43,	32720	3	9	20th July '43,	31st Aug. '42,	30th June '43,	
Retaining Dam, Nogong,	6765	0	0	ditto.	3964	0	0	ditto,	ditto,	ditto,	Lieut. A. D. Turnbull.
ditto Muskurra,	13530	0	0	2nd March '43,	10490	0	0	ditto,	30th Nov. '42,	ditto,	Serjt. Petrie.
8 Bridges Khekra Rajbuha,					513	3	8	22nd Jan. '41,	31st Jan. '38,	29th Feb. '40,	
2 ditto Kandla ditto,					348	14	5	ditto,	31st May '38,	31st Dec. '39,	
1 ditto Kirthul ditto,					61	14	5	ditto,	31st Jan. '38,	31st Jan. '40,	
2 ditto Bubeesa ditto,					128	14	0	ditto,	ditto.	ditto,	
1 ditto Burrowli ditto,					129	12	1	ditto,	31st Dec. '37,	31st March '38,	
1 ditto Husaoda ditto,					129	12	1	ditto,	30th June '38,	30th April '40,	
1 ditto Dhukowli ditto,	3800	0	0	14th Oct. '39,	45	5	4	ditto,	28th Feb. '37,	31st Jan. '40,	Mr. Sub-Condr. Brew.
2 ditto Surrowli ditto,					168	15	10	ditto,	30th June '39,	31st March '40,	
2 ditto Kotwalpoor do.,					152	12	6	ditto,	30th Nov. '37,	31st May '40,	
1 ditto Kullurpoor do,					350	1	1	ditto,	31st Jan. '40,	ditto,	
3 ditto Boonta ditto,					453	5	1	ditto,	31st March '39,	31st Dec. '39,	
3 ditto Nugla ditto,					579	0	9	ditto,	31st Oct. '39,	30th May '40,	
5 ditto Bujwarra ditto,					732	6	4	ditto,	31st Jan. '40,	30th June '40,	
Shamli Mills,	Col. Smith's Estimate,				2398	14	1	27th Feb. '34,	—— Jan. '32,	31st Oct. '32,	Mr. Sub-Condr Pigott.
Gorhni Aqueduct and Water-course,	do.,				2079	12	2	17th March '35,	—— April '32,	30th April '34,	Lieut. Napier, Assist. Superintendent.
Botanical Garden Mill,	do.,				420	11	3	22nd March '33,	—— Aug. '30,	31st July '31,	Serjt. Brew, Overseer.
Nyashur Water-course,	4052	14	0	——Dec. '35,	4030	11	3	9th May '42,	—— Dec. '35,	31st Oct. '41,	Lieut Napier, and completed by Serjt. Pigott.
Rampoor Mill,	Col. Smith's Estimate,				771	6	6	27th Feb. '34,	—— Dec. '32,	30th April '33,	Serjt. Petrie, Overseer.
Bunhera Dam and Works,	do.,				2706	15	6	11th Dec. '39,	30th April '34,	30th April '38,	Lieuts Anderson & Sturt.

N.B. Irrigation Drains and works of a similar description have not been entered in the above Table.

* After the completion of the Masonry Aqueduct, the balance of the Estimate was transferred to the Nugla Rajbuha account, to complete the Earthen Aqueduct over the valley of the Dumola River.

APPENDIX D.

STATEMENT of the Number of Irrigation Inlet and Outlet Openings from the Doab Canal, North Division, extending from the Head to the Ghoonna Bridge.

DESCRIPTION.	Length in feet, of Banks between Bridges.	No. OF OPENINGS.			
		East or Left Bank.		West or Right Bank.	
		Pucka	Cutcha.	Pucka.	Cutcha.
From Nyashur Bridge to Raipoor Bridge, . . .	7040	2	..	1	..
Gundewur ditto, . . .	16026	2	1	3	3
Belka ditto, ...	10938	..	..	1	3
Behut ditto, ...	6500	..	..	..	..
Kulsea ditto, ...	4160	..	..	..	..
Nugla ditto.	4900	2	..	1	..
Bobyl ditto, ...	10330	1	..	1	..
Rundole ditto, . . .	7750	..	..	..	..
Malaheeri ditto, . . .	5760	1	..	1	..
Ghoonna ditto, . . .	5970	1	..	1	..

(Signed) J. PIGOTT, *Overseer,*
Sub-Conductor.

STATEMENT of Irrigation Openings, Pucka and Cutcha, in Centre Division, Doab Canal, from Ghoonna to Mundait.

Camp, Berkhin, 9th November 1844.

BETWEEN WHAT BRIDGES.	NO OF OPENINGS TOGETHER				TO WHAT VILLAGES BELONGING.	TOTAL BETWEEN BRIDGES.				REMARKS.
	E. Bank.		W. Bank.			E. Bank.		W. Bank.		
	Pucka.	Cutcha.	Pucka.	Cutcha.		Pucka.	Cutcha.	Pucka.	Cutcha.	
Ghoonna and Sirkurri,	..	..	..	1	Topree,	..	..	..	..	
,, ,,	..	..	1	..	Gurdunpoor Water-course,	..	..	..	..	
,, ,,	..	..	1	..	Sirkurri ditto,	..	..	..	..	
,, ,,	1	..	..	..	ditto and Kolki ditto,	1	..	2	1	
Sirkurri and Hulalpoor,	1	..	..	..		..	..	..	..	Pandhoi Nulla Head.
,, ,,	..	1	..	..	Sooltanpoor,	..	..	..	..	
,, ,,	..	1	..	..	Duthowli,	..	..	..	..	
,, ,,	..	1	..	..	ditto,	..	..	..	..	
,, ,,	..	1	..	..	Hulalpoor,	..	..	..	..	
,, ,,	1	..	..	..	ditto Water-course,	1	4	..	..	
Hulalpoor and Adumpoor,	1	..	1	..		1	..	1	..	Situated just close to the Hulalpoor Falls.
Adumpoor and Mekchupper,	..	..	..	1		1	..	..	..	Mekchupper Rajbuha.
Mekchupper and Manukmow,	..	1	..	1	Mekchupper and Manukmow Water-courses,	..	..	..	..	Situated just above the Mekchupper Falls.
Mekchupper and Manukmow,	1	..	..	..	Manukmow Water-courses,	2	..	1	..	East Bank, Kirsunni Rajbuha Head.
Manukmow and Ruttunkheri,	1	..	1	..	Manukmow Water-courses,	..	..	..	..	
					Carried forward,	6	4	4	1	

Between what Bridges.	No. of Openings. together E. Bank. Pucka.	E. Bank. Cutcha.	W. Bank. Pucka.	W. Bank. Cutcha.	To what Villages belonging.	Total between Bridges. E. Bank. Pucka.	E. Bank. Cutcha.	W. Bank. Pucka.	W. Bank. Cutcha.	Remarks.
					Brought forward, .	6	4	4	1	
Mannkmow and Ruttunkheri, . . .	1	..	..	..	Moontazpoora ditto, ...	..	..	..	..	
,, ,,	1	..	1	..	. . . . .	..	..	..	..	
,, ,,	..	1	..	..	Kunkurala, ...	3	1	2	..	
Ruttunkheri and Reeree,	1	..	1	..	Ruttunkheri and Kunkurala Water-courses, ...	..	..	..	..	
,, ,,	..	..	1	..	ditto and Thurrowlee ditto, .	..	..	..	..	
,, ,,	1	..	..	..	Kirsunni and ditto, ...	..	..	..	..	
,, ,,	1	..	..	1	ditto, ditto, ...	..	..	..	..	
,, ,,	..	..	..	..	Reeree, ...	..	..	..	..	
,, ,,	1	..	1	1	Reeree Water-courses, . . .	4	..	3	1	
Reeree and Balpoor, . .	..	..	..	..	Laloomajra, ...	..	..	..	..	
,, ,,	..	2	..	1	Nulhera, ...	..	..	..	..	Islamnuggur Rajbuha.
,, ,,	..	..	..	..	Saijwa, ...	..	..	..	..	These openings might be abolished, as the Rajbuha can irrigate the
,, ,,	..	1	..	..	Kabeer Majra, ...	..	..	..	..	whole of the Saijwa Rukba.
,, ,,	..	1	..	..	Mohunpoor, ...	..	..	..	..	
,, ,,	..	..	1	1	. . . . .	..	..	..	..	
,, ,,	..	..	..	1	Saijwa, ...	..	..	..	..	
,, ,,	..	..	..	..	ditto, ...	..	..	..	..	
,, ,,	1	..	1	..	Balpoor & Nyagaon Water-courses,	1	4	2	4	
Balpoor and Myhee, . .	..	..	..	1	Nyagaon, ...	..	..	..	..	
,, ,,	..	..	..	1	Myhee, ...	..	..	..	..	
,, ,,	..	2	..	..	Dheree and Bhankla, ...	..	..	..	..	
,, ,,	..	..	..	1	Myhee, ...	..	..	..	..	
,, ,,	..	2	..	..	Rajoopoor, ...	..	..	..	..	

,,	,,	1	..	1	..	Myhee Water-courses, . . .	1	4	1	3	Run only with a very high supply.
Myhee and Nowrungpoor,		..	..	1	..	ditto ditto, ...	..	..	..	..	
,,	,,	..	..	..	1	Myhee, ...	..	..	..	..	
,,	,,	..	..	..	1	ditto, ...	..	..	..	..	
,,	,,	..	1	..	..	Khanpoor, ...	..	..	..	..	
,,	,,	..	..	..	1	Kheree, ...	..	..	..	..	
,,	,,	1	..	..	..	. . . . .	1	1	1	3	
Nowrungpoor & Rampoor,		..	..	..	1	Nowrungpoor.	..	..	..	..	Rampoor Rajbuha.
,,	,,	..	..	..	1	Dukrowar-Kullan, ...	..	..	..	..	
,,	,,	..	2	..	..	Nowrungpoor and Rampoor,	..	..	..	..	
,,	,,	..	1	..	..	Kishun Kheree, ...	..	..	..	..	
,,	,,	..	..	..	3	Majree and Dukrowlee, . . .	..	..	..	..	
,,	,,	..	..	..	2	Mokunpoor, ...	..	..	..	..	
,,	,,	..	..	..	1	Rampoor, Sanchloo, and Majree,	..	..	..	..	
,,	,,	..	2	..	..	Rampoor, ...	..	5	..	8	This Head has 3 Water-courses.
Rampoor and Kullurpoor,		..	1	..	..	Rampoor, ...	..	..	..	..	
,,	,,	..	..	..	3	Salaimpoor and Sanchloo, . .	..	..	..	..	
,,	,,	..	3	..	..	Rampoor, Kunjowlee, & Meerpoor,	..	..	..	..	
,,	,,	..	..	..	1	Kullurpoor, ...	..	..	..	..	
,,	,,	..	1	..	..	ditto, ...	..	5	..	4	
Kullurpoor and Abba,		1	..	1	..	West Bank Dhakadi Water-course,	..	..	..	..	
,,	,,	..	..	..	1	Puthanpoora, ...	1	..	1	1	East Bank, Kullurpoor Rajbuha.
Abba and Nynpoor,		..	..	..	1	Abba, ...	..	..	..	..	
,,	,,	..	1	..	..	ditto and Nynpoor, ...	..	..	..	..	
,,	,,	..	..	..	4	Teekrole, Hyderpoor, & Chuchraoli,	..	1	..	5	
Nynpoor, & Bahmunmajra,		..	..	..	5	ditto, ditto, ditto, and Nynpoor,	..	..	..	..	
,,	,,	..	..	..	4	ditto, Burses, and Nynpoor, .	..	..	..	..	
,,	,,	..	..	..	6	ditto, Bahmunmajra and Oleree.	..	..	..	..	
,,	,,	..	2	..	..	Nynpoor and Oleree, ...	..	..	..	..	
,,	,,	..	3	..	..	Nanouta, Pandokhera & Kotubpoor,	..	5	..	15	
Bahmunmajra and Bursa,		..	4	..	..	Nanouta, ...	..	..	..	..	
						Carried forward, . .	17	30	14	45	

Between what Baidges	No of Openings Together E. Bank Pucka	E. Bank Cutcha	W. Bank Pucka	W. Bank Cutcha	To what Villages belonging	Total between Bridges E. Bank. Pucka	E. Bank. Cutcha	W. Bank. Pucka	W. Bank. Cutcha	Remarks
					Brought forward, . .	17	30	14	45	
Bahmunmajra and Bursa,	..	..	..	1	Bursa, ...	..	..	..	..	
,, ,,	..	4	..	..	Nawuta and Bukrowlee, . .	..	..	..	..	
,, ,,	..	..	..	1	Landhoura.	..	..	..	..	
,, ,,	..	2	..	..	Bukrowlee and Emampoor . .	..	..	..	..	
,, ,,	..	..	..	1	Landhoura.	..	..	..	..	
,, ,,	..	..	..	1	ditto and Bursa, ...	..	..	..	..	Madhoopoor Rajbuha.
,, ,,	1	..	..	..	. . . . .	..	..	..	..	
,, ,,	..	..	..	1	Landhoura, ...	..	..	..	..	
,, ,,	..	2	..	..	Madhoopoor, and Dadunpoor, .	..	..	..	..	
,, ,,	..	..	..	1	Bursa, ...	..	..	..	..	
,, ,,	..	..	..	1	Jhinderi, ...	..	..	..	..	
,, ,,	..	1	..	..	ditto, ...	1	13	.	7	
Bursa and Poojna,	.	..	..	3	Munora, Bursa, and Thola, . .	..	..	..	..	
,, ,,	..	1	..	..	ditto, ...	..	..	..	..	
,, ,,	..	..	..	1	Sheipoor Madhoopoor, . . .	..	..	..	..	Teetroon Rajbuha.
,, ,,	..	..	..	1	. . . . .	..	..	..	..	
,, ,,	..	..	..	5	Munora, ...	..	..	..	..	
,, ,,	..	2	..	..	Yeheeapoor and Bharee, . . .	..	..	..	..	
,, ,,	..	..	..	2	Poojna and Munora, ...	..	..	..	..	
,, ,,	..	1	..	..	ditto, ...	..	..	..	..	
,, ,,	..	4	..	..	Bhabsee, Poojna, and Gundeora,	..	8	..	8	
Poojna and Berkheri,	..	2	..	..	ditto and Bhabsa, ...	..	..	..	..	
,, ,,	..	..	..	4	Teetroon, Papree, and Poojna, .	..	..	..	..	
.	.	1	.	1	Papree	..	..	..	..	
					Bhabsa and Berkheri . .	.	.	..	..	

„ „	..			1	[illegible]			..		
„ „		.	.	2	Gurhi and ditto,		..		..	
„ „	.	..	..	1	Berkheri,	..	3	.	10	
Berkheri & Manukpoor,	..	..		1	Berkheri,	..	..	..	..	
„ „	..	1	..	..	Gundeora,	..	..	..	..	
„ „	..	1	..	.	ditto,	..	..	..	..	
„ „	..	..	..	1	Pi'kheri,	.	..	..	..	
„ „	..	1	..	..	ditto	.	..	..	..	
„ „	..	..	1	..	. . . .	.	..	.	.	Boonta Rajbuha.
„ „	..	1	..	..	Manukpoor,	.	4	1	2	
Manukpoor and Kheera Gudai,	..	1	..	..	Bundhera,	..	..	..	..	
„ „	..	1	..	..	Manukpoor,	..	..	..	.	
„ „	..	1	..	..	Beneheea,	..	..	..	..	
„ „	..	1	..	..	Yarpoor,	..	..	..	..	
„ „	..	1	..	..	ditto,	.	..	..	..	
„ „	..	2	.	..	Nowjul and Kheera Gudai,	..	..	..	.	
„ „	..	..	..	1	Kheera Gudai,	..	7	..	1	
Kheera Gudai and Kyl,	..	..	..	1	Kyl,	..	..	..	.	
„ „	..	..	..	2	Gurhi and Rajhur,	..	..	..	.	
„ „	..	1	..	.	Kyl,	..	..	..	..	
„ „	..	..	..	3	ditto and Nyagaon,	..	1	..	[illegible]	
Kyl and Tirwa,	..	1	..	..	Kyl,	..	..	..	..	
„ „	..	1	..	..	ditto,	..	.	..	..	
„ „	..	..	..	1	Nyagaon,	.	..	..	..	
„ „	1	..	..	..	. . . .	1	2	..	1	Sulawur Rajbuha.
Tirwa and Jhunderi,	..	..	..	1	Mulhendi,	..	..	..	..	
„ „	..	1	..	..	Mustghur,	..	..	..	..	
„ „	..	1	..	..	Jusana,	..	..	..	..	
„ „	..	..	..	1	Bynswal,	..	..	..	..	
	..	1	..	..	Dhunyna and Sulawur,	..	..	..	..	This head has 3 Water-courses.
					Carried forward, ...	19	68	15	80	

Between what Bridges.	No. of Openings together. E. Bank. Pucka.	E. Bank. Cutcha.	W. Bank. Pucka.	W. Bank. Cutcha.	To what Villages belonging.	Total between Bridges. E. Bank. Pucka.	E. Bank. Cutcha.	W. Bank. Pucka.	W. Bank. Cutcha.	Remarks.
					Brought over, .	19	68	15	80	
Tirwa and Jhinderi,	..	..	..	1	Bynswal, ...	..	3	..	3	This head has 3 Water-courses.
Jhinderi and Bynswal,	1	..	..	..	Mundate, Shamli, Sulawur, Kurori, Gorhni; Dhunyna, and Bynswal Water-course, .	..	..	..	..	Shamli Escape.
" "	..	..	..	2	Bynswal, ...	..	..	..	..	
" "	1	..	..	..	Bynswal Water-course, . . .	2	..	..	2	
Bynswal and Bunnut,	1	..	..	..	ditto ditto, . . .	..	..	..	..	
" "	..	..	1	..	ditto ditto, . . .	..	..	..	..	
" "	1	..	..	..	. . . . .	2	..	1	..	Gorhni Rajbuha.
Bunnut and Mundate,	1	..	1	..	Bynswal Water-course, . .	..	..	..	..	
" "	..	..	..	1	Bynswal, ...	..	..	..	..	
" "	1	..	..	..	Gorhni Water-course, . . .	..	..	..	..	
" "	..	..	1	..	Budhee ditto, ...	..	..	..	..	
" "	..	..	..	2	ditto ditto, ...	..	..	..	..	
" "	..	2	..	..	ditto ditto, ...	2	2	2	3	
					Grand Total,....	25	73	18	88	

Camp, Berkheri,
November 10, 1844.

W. E. MORTON, *Lieut.*
Assist. Ex. Eng. D. C.

STATEMENT of the Number of Irrigation Openings from the Doab Canal, South Division, Rajbuha Heads and Drains, both Pucka and Cutcha, &c., &c.

Camp, Surrowli, 30th October, 1844.

No.	DESCRIPTION.	Length in feet of Bank between Bridges	No. OF OPENINGS.				REMARKS.
			E Bank.		W. Bank.		
			Pucka.	Cutcha.	Pucka.	Cutcha.	
1	Mundait to Shamli Meerut Bridge, . . .	4400	2	..	1	1	2 Shamli Mill Heads, East Bank.
2	Meerut Shamli to Kheeri, ...	7900	..	5	..	10	
3	Kheeri to Lalooen, ...	6558	..	5	..	8	
4	Lalooen to Kundraoli North, ...	8692	1	..	1	..	
5	Kundraoli North to Kundraoli South, .	2990	..	1	..	..	
6	Kundraoli South to Punjokri, ...	17137	3	1	3	8	Kandla Rajbuha Head, West Bank.
7	Punjokri to Kandla, ...	6816	2	1	2	..	Bubeesa Rajbuha Head, East Bank.
8	Kandla to Bharsi, ...	3450	1	2	..	1	
9	Bharsi to Nalla, ...	12438	1	3	..	9	Bunhera Rajbuha Head, East Bank.
10	Nalla to Kukripoor, ...	10175	1	5	1	6	Kirthul Rajbuha Head, West Bank.
11	Kukripoor to Romalla, ...	11668	1	3	1	7	
12	Romalla to Bural, ...	9590	2	4	1	6	1st Head Bujwarra Rajbuha, East Bank.
13	Bural to Baoli North, ...	17824	1	14	..	15	2nd Head Bujwarra Rajbuha, East Bank.
14	Baoli North to Baoli South, ...	3170	1	..	1	1	
15	Baoli South Mulickpoor, ...	13892	..	9	..	9	Loen Rajbuha Head, West Bank.

No	Description.	Length in feet, of Bank between Bridges.	No. of Openings. E Bank. Pucka.	E Bank. Cutcha.	W. Bank. Pucka.	W. Bank. Cutcha.	Remarks.
16	Mulickpoor to Barote,	2268	..	1	2	..	Burrowli Rajbuha Head, West Bank.
17	Barote to Burrowli,	4181	1	1	..	4	
18	Burrowli to Lawulpoor,	17254	1	11	1	12	
19	Lawulpoor to Bichperi,	16432	..	12	1	15	1st Head Khekra Rajbuha, West Bank.
20	Bichperi to Basode,	13055	1	12	1	11	2nd Head Khekra Rajbuha, West Bank. — Husaoda Rajbuha Head, East Bank.
21	Basode to Deola,	8680	2	3	2	3	Deola Rajbuha Head, East Bank.
22	Deola to Kutta,	15150	2	5	1	7	Dhukowli Rajbuha Head, East Bank.
23	Kutta to Muhrumpoor,	6800	1	4	1	5	
24	Muhrumpoor to Burragaon,	10725	..	6	..	11	
25	Burragaon to Mobarukpoor,	7590	1	5	1	5	
26	Mobarukpoor to Rutoul,	7843	..	3	1	7	Surrowli Rajbuha Head, West Bank.
27	Rutoul to Surrowli,	14512	..	4	..	3	
28	Surrowli to Sookulpoor,	10031	1	1	1	1	Kotwalpoor Rajbuha Head, East Bank.
29	Sookulpoor to Sikrani,	4178	..	..	1	..	Cherouri Inlet, or Tail Khekra Rajbuha.
30	Sikrani to Jaoli,	7132	..	..	..	2	
31	Jaoli to Gokulpoor,	20223	1	3	1	4	
32	Gokulpoor to Selimpoor,	17005	..	11	..	5	
	Total,	319768	27	135	25	176	

H. B. BREW, *Sub-Condr.*,
Doab Canal.

APPENDIX G.

STATEMENT of Cost and Returns on the Doab Canal up to the 1st of May 1844.

	Dead Stock.			Current Expenditure, viz. Ordinary repairs, Establishment, per centage on Water and Mill Rent, Compensation for land occupied and destroyed, &c.			Gross Revenue.			Net Revenue.			Interest on account of Dead Stock as on 1st May 1843, at 5 per cent.			Clear profit on Canal, beyond the Interest.			Remarks.
To'al up to 1st May 1843, . .	645071	6	6	878574	13	2	823045	3	2										
Add for 1843-44,.	97417	1	2	67393	9	11	100763	9	3	33369	15	4	32253	9	2	1116	6	2	
Total up to 1st May 1844, . .	742488	7	8	945968	7	1	923808	12	5	...	...	..	32253	9	2	...	...	...	

Current Expenditure, &c., ...	945968	7	1
Gross Revenue, ...	923808	12	5
Deficit, ...	22159	10	6
Add Interest at 5 per cent., ...	32253	9	9
Total Deficit up to 1st May 1844, ...	54413	3	8

R. BAIRD SMITH, *Lieutenant,*
Executive Engineer, Doab Canal.

The Doab Canal on the 1st of May 1844 including interest on Dead Stock, has still a balance against it amounting to Rs. 54,413-3-8, the Net Revenue however is on the increase, not only in Returns on water-rent, &c., but also in a reduction in the expenses or new works and ordinary repairs. The heavy expenditure both on Dead Stock and Current outlay during the year 1843-44, has checked the progress of liquidation, but the debt which has been annually decreasing will be cleared off at an early period. I have, as supplementary to this, given a corresponding table for the Canals westward of the Jumna, these are on a scale of much greater extent, and are understood to consume a supply of water four times greater than that of the Doab Canal, the latter was opened in 1830, the Canals westward of the Jumna, including the Delhi or Alli Murdan Khan's and Feroze's Canals, were opened at two different periods, the first in 1819, and the latter in 1825.

P. T. CAUTLEY, *Captain,*
Supt. Canals, Doab, &c.

STATEMENT of Cost and Returns, Canals West of the Jumna, up to the 1st of May 1844.

	Dead Stock.			Current Expenditure, viz. Ordinary repairs, Establishments, per centage on Water and Mill Rent, Compensation for land occupied and destroyed, &c.			Gross Revenue.			Net Revenue.			Interest on account of Dead Stock as on 1st May 1843, at 5 per cent.			Clear profit on Canal, beyond the interest.		
Total up to 1st May 1843, . .	1109747	5	11	1918539	2	0 1/8	3052811	1	4	1134271	15	3 3/8						
Add for 1843-44,	8408	11	9	98063	4	6	290993	10	5	192930	5	11	55487	5	11	137443	0	0
Total up to 1st May 1844, . .	1118156	1	8	2016602	6	6 1/8	3343804	11	9	1327201	5	2 3/8	55487	5	11	137443	0	0

(Signed) A. H. E. BOILEAU, *Captain, Engineers,*
Offg. Supdt. of Canals, West of the Jumna.

(True Copy,)

P. T. CAUTLEY, *Captain,*
Supdt. Canals, Doab, &c.

APPENDIX H.

STATEMENT of Expenditure and Number of Trees alive in the Plantations forming along the banks of the Doab Canal, from the 30th April 1835 to the 30th April 1844.

Doab Canal Office, 1st May 1844.

	NORTH DIVISION.			CENTRE DIVISION.			SOUTH DIVISION.			GRAND TOTAL.				
	Half Yearly Outlay		Number of Trees at the end of Half Year.	Half Yearly Outlay.		Number of Trees at the end of Half Year	Half Yearly Outlay.		Number of Trees at the end of Half Year.	Expenditure as per Bills rendered.		Number of Trees as per Statement forwarded	Estimated value of the Trees in the Plantations.	Amount realized by sale of Canal Produce.
Total from 1st May 1835 to 30th April 1843,	2117	7 10½	22202	3268	15 1	76180	2766	11 6½	136845	8153	2 6	235227	30000 0 0	9872 4 4
1st May 1843 to 31st Octr 1843,	240	7 11	...	398	12 0	...	460	10 8	...	506	10 4	...	... ...	1325 9 6
1st Nov. 1843, to 30th Apl. 1844,	817	6 0	26267	546	12 8	92845	673	3 6	141668	2630	10 5	260780	50000 0 0	86 2 0
Total up to 30th April, 1844,.....	3175	5 9½	26267	4214	7 9	92845	3900	9 8½	141668	11290	7 3	260780	50000 0 0	11283 15 10

Cash drawn from Treasury since 30th April 1835, ... 13000 0 0

Amount of Bills rendered as above, ... 11290 7 3

Balance in hand on the 30th April 1844, ... 1709 8 9

R. BAIRD SMITH, *Lieut.*
Exec. Engineer, Doab Canal.

P. T. CAUTLEY, *Capt.*
Supdt. Canals, Doab, &c.

APPENDIX I.

RATES of Water-rent levied on Lands Irrigated from the Doab Canal, according to the value of the Crops grown, and relative facilities for using the Water.

		On Lands Irrigated naturally.						On Lands Irrigated artificially.						
		Per Beegah.			Per Biswa.			Per Beegah.			Per Biswa.			
1st Class,	Fruit, Gardens or Orchards, ... Ditto, ditto, with Vegetables underneath, Nursery Gardens,..	3	2	0	0	2	6	2	8	0	0	2	0	Per annum
2nd Class,	Vegetable Gardens, ... Fruit Trees with Grain underneath, ... Indigo, Sugar Cane, Tobacco, Singharas, Cultivated Grasses, Ujwain, Mussallas, ..	1	4	0	0	1	0	0	15	0	0	0	9	Per annum or Crops.
3rd Class,	Rice, Cotton, Wheat, Oats, Indian Corn, Gochni, ... Vegetables, single crops, Safflower, Urruhr,	0	10	0	0	0	6	0	6	8	0	0	4	Per Crop.
4th Class,	Gram, Barley, Oil Seeds of varieties, Cheena, Mundowa, Jowar,.. .. .. Dals of varieties, Bajra, Mote, ...	0	6	8	0	0	4	0	5	0	0	0	3	Per Crop.

The Beegah is considered as that of 55 yards square.

P. T. CAUTLEY, *Capt.*
Supdt. Canals, Doab, &c.

APPENDIX K.

RATES of Transit Duties on the Doab Canal, from the Jumna at the Canal Head, to the Selimpoor Mills opposite Delhi.

(Intermediate distances to pay the intermediate proportions.)

ALL RATES ON THE CORGE OR 20 IN NUMBER.

	R.	A.	P.
Saul Timbers, above 5 feet in girth, per 20,	40	0	0
„ 4 feet to 5, ditto,	30	0	0
„ under 4 feet, „	20	0	0
Toon Timbers, above 5 feet, „	30	0	0
„ under 5 feet, „	20	0	0
Sissoo Timbers, above 4 feet, „	20	0	0
„ under 4 feet, „	10	0	0
„ under 3 feet, „	5	0	0
Babool Timbers or Spars,	5	0	0
Ash Spars,	10	0	0
Fir Spars,	10	0	0
Saul Golahs, large,	10	0	0
„ „ small,	5	0	0
„ Bullahs,	5	0	0
„ Bullies,	0	10	0
„ Pharras, above 12 feet long,	2	8	0
„ „ 9 to 12 ditto,	1	14	0
„ „ under 9 feet ditto,	1	4	0
„ Kurries, above 12 feet,	1	4	0
„ „ 9 to 12 feet,	0	15	0
„ „ under 9 feet,	0	10	0
„ Toors,	0	15	0
„ Plank pieces, above 2½ feet girth or Saul Sillis,	5	0	0
„ „ under ditto, ditto,	2	0	0
Bamboos, per 100,	0	8	0
Firewood, per 100 Maunds,	1	0	0
Surkunda grass, per 100, 1 Rupee; per 1000, 8 Annas,	1	0	0
Moonje and Bhabur, per 100 Maunds,	1	0	0

Saul Timbers cut into planks to pass as Timbers according to quality, if the planks are separate, the number and length, breadth, and thickness to be written in the Rowannas.

(Signed) J. COLVIN, *Captain*,
Supdt. Canals, Delhi Territory, &c.

The proportions on the above Rates are as follows:—

From the Canal Head	to Kulsea, ...	One Tenth.
Kulsea	to Manukmow, . . .	ditto.
Manukmow	to Abba, ...	ditto.
Abba	to Berkheri, ...	ditto.
Berkheri	to Bynswal, ...	ditto.
Bynswal	to Kandla, ...	ditto.
Kandla	to Barote, ...	ditto.
Barote	to Deola, ...	ditto.
Deola.	to Surrowli, ...	ditto.
Surrowli	to Selimpoor, ...	ditto.

The passage of locks will be subject to an additional charge on each ascent, or descent, or on each filling of the lock-chamber as will be hereafter rated.

(Signed) P. T. CAUTLEY, *Capt.*,
Supdt. Doab Canal.

In issuing the Rowannas or Passes, the following Rules are to be adhered to, and explained to the owners of Rafts.

1st. Rafts are not to be landed except at the places specified in the Rowanna, by landing is meant finally taking them out of the Canal, under penalty of infraction of triple duties.

2nd. If more Timber be carried down under a Rowanna than is specified therein, the surplus to pay double duty. If less Timber than is specified, the rafts to pay according to the Rowanna.

3rd. If the Timber of any rafts having arrived at its destination is removed in whole or in part, without having been searched by the Zilladar of the district or a Chuprassi sent by him, the portion removed will be liable to triple duties.

4th. Any open attempt at wilful fraud, when proved, will be punished by the forfeiture of the Timber.

5th. Rafts on reaching their destination must be taken out of the water without loss of time, if unnecessary delay takes place, people will be hired to take them out, and the cost charged to the owners of the raft.

6th. No wood rafted down the Canal for any purpose, or for any person whatever is exempt from the duty, nor can any be passed without a regular Rowanna, which will be given by Serjeant Pigott, or the Overseer in charge of the North Division, and none else are of any use except such as may be issued direct from the office for any part of the Canal.

7th. Injury to the bridges and masonry works will make the owners of rafts liable to the penalty of repair, and wanton damage caused by the carelessness of rafters in not moving properly, and allowing their rafts to run adrift, &c., will entail an additional penalty equal to the amount of injury done.

P. T. CAUTLEY, *Capt.*
Supdt. Doab Canal.

February 12th, 1845.

WATER-COURSES

IN THE

DEYRA DOON.

DEYRA DOON WATER-COURSES.

It is hardly possible to conceive a tract of country more gifted by nature in its configuration, profile of surface, and possession of perennial streams, than the valley of Deyra—extending between the Ganges and Jumna rivers which bound it on its east and west, it is confined towards the north by the Himalaya, and towards the south by the Siwalik hills. Its total breadth is about 48 miles, and the length or distance between the two ranges varies from 10 to 15.

2. At a point nearly centrical between the Ganges and Jumna rivers, the valley is considerably elevated; this elevated land extends from the Siwaliks to the Himalaya, and divides the valley into two portions and two distinct slopes of drainage, that towards the Ganges being designated in the revenue maps the eastern, and that towards the Jumna the western Doon.

3. At a point on this elevated ridge near an artificial hollow or tulao called the Bheem Tal, the Asun and Sooswa rivers rise, the former after receiving the drainage from its north and south tributaries, falls into the Jumna, and acts as the escape for the western Doon; whilst the Sooswa which in its course connects itself with the Song, a river which rises in the southern slope of the Himalayas with similar tributaries, drains the eastern valley into the Ganges. The Sooswa loses its name after this junction, the united drainage falling into the Ganges river under the name of the Song.

4. The valley therefore is divided naturally into four portions,

each of which has a perennial stream on its whole length. The tributaries which rise in the mountains to the north and south of these streams, are in most cases dry at all periods excepting during the rains, although some of them, especially on the Himalaya slope, have water in the earlier parts of their courses, which disappears through their shingle beds long before they reach the main river. This is the case with the Tonse, a river which (similar to the Song in the eastern Doon,) rises in the southern slope of the Himalaya under the Mussoori ridge; the Tonse is a portion of the drainage of the western Doon and falls into the Asun; during the dry months there is no water in the lower part of its course, whilst in the upper, the stream is sufficient to supply irrigation to a considerable tract of country.

5. The declivity of the beds of the Asun and Sooswa rivers, from their spring heads near the Bheem Tal, to their junction with the Jumna and Ganges rivers, was fixed by the late Captain Herbert as follows:—

Total fall from the head of the Asun to the Jumna river, 652 ft.
Total fall from the head of Sooswa to the Ganges river, 918 ft.

The distance in the first case being about 23, and in the latter 25 miles, and the declivity per mile being 28·34 and 37·9 feet, respectively; there is no reason whatever to doubt the accuracy of Captain Herbert's observations, which appear to be borne out, by the extreme tortuosity as well as by the numerous rapids that exist on both these rivers.

6. From the description above given, it will be evident that all the elements required for an extensive system of irrigation are naturally provided—and that a judicious application of skill and capital was only required to turn them to the best account.

7. The natives had by no means overlooked the value to be derived from using the waters from the different streams in irrigation—besides, a water-course taken from the Ruspunna river to the town of Deyra (which is situated on the central elevated land be-

fore alluded to)—numerous water-courses exist both on the Asun, Sooswa and Song rivers, and even on the high lands in their neighbourhood—the remains of others, and even of masonry works on a small scale, attest the extent to which irrigation had been carried at former periods, and an attempt had been made to take possession of the water at the head of the Tonse river, and to introduce it on the high land between that river and the Bindal, another ravine or river which is connected with the eastern drainage. Tradition existed of this having been effected, and that the work went to ruin in consequence of feuds between rival Zumeendars,—this, however, is doubtful, from circumstances which came to notice afterwards.*

Beejapoor Water-course—Estimate submitted April 1838.

8. At the end of 1837,† I was directed to proceed to the Doon, and survey and report on the practicability or otherwise of making use of the water of the Tonse; my reports, plans, and estimates, were submitted in April of the following year. The estimate "of the probable expenses to be incurred in opening a water-course from the village of Beejapoor in the Deyra Doon, for the irrigation of lands lying between the Tonse, Asun and Bindal rivers," amounted to rupees 13,955-5-10.

* In the face of a rock about half a mile from the Purotewalla Ghat, there was a very distinctly carved channel, of about 2½ feet wide and six inches deep—with the exception of this mark, and some indistinct traces more like a foot-path than a water-course, the line was lost long before it reached the anticlinal ridge at Purotewalla, as the true level of the water-course carved out of the rock was, agreeably to my levels, many feet below the crest of the Purotewalla ridge, and as at that point there were no signs of tunnelling or other work by which the water could have passed, I infer that the water-course was never completed, and that the work was stopped before it reached Purotewalla.

† The opening out of this Canal had always been advocated by the different Canal Authorities in the Doon—Messrs. Calvert, Christian, Moore, Shore, and utterly by Colonel Young, to whose suggestions and recommendations, the provision of funds for the execution of the present work is undoubtedly due.

Description of the Tonse River, from which the Beejapoor Water-course is supplied.

9. The Tonse river is a rapid stream, receiving its supply from the drainage of the Karkooli valley immediately south of and under the Mussoori ridge, and as I have before described in para. 4, terminates in the Asun river. At the point where I determined on establishing the head of the water-course, the section of the river was abrupt, and the declivity of bed very great, exhibiting all the characteristics of a mountain torrent in the proximity of its water heads. The transverse section of the channel, (with the exception of that portion under Purotewalla, where the river passes through a small valley cultivated with rice,) from the above point to the south of the village of Kowlageer, is precisely that of a ravine; the stream having carved for itself a channel through a shingle conglomerate to a depth of from 60 to 120 feet—at some places this ravine is wide, at others narrow and confined—but the sides are usually mural cliffs with occasional gorges (one of which I measured and found to be only 27 feet wide), through which the torrent had forced itself a passage. From the circumstance of the horizontal stratification of this conglomerate, and the variety of texture and induration of the different strata, the action of weather and the water of the river by removing the softer rock, gives these ravines the most picturesque and fantastic outline; huge tabular masses of rock projecting themselves forward, without any support further than their own tenacity, and corresponding caverns, many of them fruitful in stalagmitic deposits, crowned as they are with forest and the richest vegetation, render the neighbourhood an interesting resort to travellers whether interested in the works of the Beejapoor water-course or not.

Material.

10. The boulders or masses of stones in the bed of the river were (in a proportion of at least one-fourth) lime rock; wood for kilns, either brick or lime was in abundance; brick earth was at hand; and as far as

material was concerned every thing was favorable. Labor however was dear, and without paying a high rate, the laborers to be procured in the neighbourhood were of an inferior class, and ultimately it was found advantageous to procure them from the plains.

Supply of water and capabilities of the Tonse as a feeder.

11. The supply of water when the measurement of discharge was made on the 23rd January 1838, was 24 cubic feet per second, the season had been a remarkably dry one, and it might be inferred therefore that this was the minimum discharge of the river. The Nulota, a small tributary which enters the Tonse a little way above Beejapoor, gives a very small although perennial stream, the Noon and other feeders joining the Tonse south of and below the head of the water-course, are of no consideration whatever. Previously to the construction of the present work, the waters of the Tonse were drawn off for irrigation on the small spots or flats on the line of river, a good deal of its volume was expended in turning water-mills, and a considerable portion was wasted in inundations, arising from the carelessness of the millers and cultivators. In the month of January, when I surveyed the line of river, the stream ceased at a point about five miles below the head of the water-course, from whence to its junction with the Asun river the broad and straggling bed of the Tonse was quite dry.

Tract of country to be immediately benefitted by the Beejapoor water-course.

12. The tract of country which is irrigated by the Beejapoor water-course, lies immediately westward of the town of Deyra, from which it is separated by the Bindal river or ravine, its shape is triangular, the Bindal, Tonse and Asun rivers forming the three sides of the triangle. The ground is high, with the exception of a portion of low or Kadir land which lies westward of the Nuthoowalla Ghat, at the angle formed by the junction of the Tonse with the Asun river, The slopes of surface may, in a general way, be described as running from north to south,

and from north-north-east to south-south-west, or in other words, in the general direction of the drainage of the valley. The superficial area of land coming under the influence of irrigation, may be estimated at 12,000 pucka beegahs of 55 yards square, or 7,500 acres, making deductions for area occupied by ravines and land which could not be cultivated.

Description of the work as completed.

13. The first mile of the water-course from the point where it leaves the Tonse, immediately under the village of Beejapoor, (and at which point the supply is obtained by a temporary bund thrown across the bed of the river, which delivers the water into the funnel-shaped mouth of the masonry channel,) runs along the slope and scarp of the left bank of the ravine. Near and under the village of Purotewalla, the precipices are quite perpendicular, but after passing an anticlinal ridge or ghat at that village, and overcoming some difficulties arising from irregularities of surface, the channel opens out upon the high land at Dhakra, and is carried in a straight direction upon the village of Gurhi, at which point it is divided into two branches, viz. the eastern or Kaonli branch, which extends towards the Bheem Tal, and throws its tail water into the tank and ultimately into the Asun river—and the western or Meetaburri branch, which is projected towards the Nuthoowalla ghat and the western angle of the triangle.

14. It is unnecessary to lay any particular stress upon each improvement that has been made since the original execution of the work, further than that it was necessary to build masonry falls for the water in its passage onwards from Dhakra, instead of using loose stone and piles as was at first proposed; and that instead of the original tunnel at Dhakra which was made of timber, a masonry one has been substituted. The water-course in short at this period, consists of a masonry channel 5 feet wide and 2½ and 3 feet deep, from the head to Dhakra, a distance of about 1½ mile: projected on a slope of 1·5 inches per 100 feet or 6·6 feet per mile: this

channel gradually creeps out of the valley, hugging the side of the slope and precipices, protected by under-drains at some points, and over-drains, which act also as bridges at others; where solid sound foundations were externally procurable, revetments were raised to support the channel, when this was not the case, the masonry scarp was blasted, and the channel built internally—the anticlinal ridge at Purotewalla was pierced by a masonry tunnel, and the Dhakra ravine and ridge were passed, the first by an aqueduct, and the second by a tunnel, the length of the latter being between 5 and 600 feet: just beyond the tunnel, and at the point where the water-course opens out upon the high land, the masonry channel terminates in flour mills; beyond this there is merely excavation with masonry falls*—the slope of bed intermediately between each fall being 1·5 inches per 100 feet, or 6·6 feet per mile.

15. Opposed to a mountain torrent like that of the Tonse, there was some danger to be apprehended to the head or inlet of this water-course, as for the first 6 or 800 feet in length it was liable to be overtopped during floods, and with a current passing over it due to the excessive declivity of the bed of the river, the channel might be so far injured as to interfere with the uses of the water-course during the Khurreef or rain crops, when irrigation is most especially required. Advantage therefore has been taken of some huge masses of rock which had fallen into the bed of the torrent, and which were lying close by the left side of the bank, with the stream rippling through the fissures below; behind these masses which act as a breakwater and as an admirable protection against the rush of the torrent during floods, the masonry work at the head was constructed, and the channel which is built close to the rocky precipice, which at some places hangs completely over it,

* There are 96 masonry falls on this work, varying from 2½ to 8 feet in height, and from Dhakra to the lowest falls in the Meetaburri branch on a distance of 3 miles, 5 furlongs, 144½ yards, there is a total descent of 281·57 feet, including 63 of the above falls.

was strengthened on the river side by a strong revetment, formed in a talus towards the bed of the river; this talus is continued from the head to a point where the water-course passes between the scarp of the ravine, and another huge fragment of rock, which is separated from the mountains: in this narrow gorge a masonry bar has been built with an archway for the water-course, so that in the advent of excessively high floods, the admission of water may be regulated. This is a very useful work, as floods *have* occasionally risen high upon the fragment of rock, as has been conspicuously shewn by the trunks of trees and rubbish thrown upon its top. I refer especially to these arrangements as the natural observations that appear to strike people who visit these works, are *first*, that the head would be *greatly improved* by removing the masses of rock which lie across its mouth, and *secondly*, that the bar above alluded to is an absurdity, as the flood-water never could rise to such an extreme height. When the water-course has passed this bar, the channel may be considered as out of the influence of river floods, above which it gradually rises, until in passing round the perpendicular cliffs under Purotewalla, it has obtained an elevation of at least 100 feet above the bed of the river—it will be obvious that from the position of this channel, it must be constantly liable to accidents from avalanches or slips from the sides of the hills* —it is singular however how few accidents of this sort have occurred; great attention however ought to be given to the probability of such occurrences, and every arrangement made either to check or to neutralize the evil: it is not merely that danger is to be apprehended from a cliff falling and carrying the channel away, this is by no means the only evil, a very small quantity

* The plan of making catch-drains along the top of the cliff so as to confine the drainage to points prepared for its reception, has been very successfully practised by Captain Kirke. These drains ought to be constantly watched and repaired. The cultivators must also be prevented from throwing boulders over the precipice which in clearing their fields they are much inclined to do.

of earth falling down into the water-course would act as a bund, and the stream by rising over the edge or revetment might undermine the foundations, and do an infinity of injury ; the more outlets or escapes therefore that can be built in well secured situations, the better, so as to give means of relieving the channel from superfluous water at numerous points—where the bank or scarp looks dangerous, and shews an inclination to fall, strong planks ought to be laid across the top of the water-course channel, so that the debris may not interfere with the water. Tails of escapes must be anxiously watched and promptly attended to and repaired, at many places the escape water falls upon rock, at some however this is not the case, and the action of water passing over an almost perpendicular bank is very dangerous—this is especially the case at the Badshahpoor Ghat, where a bridge constructed over the water-course acts during the rains an an aqueduct for the drainage—very severe cutting has taken place at this point, as is exhibited in a deep ravine with a forked head which is rapidly approaching the masonry channel; this, if properly attended to can be easily remedied, as fortunately there is no want of either stone or wood at this point of the work ; where such can be carried into execution, and where rock exists, escapes are more securely made on the left or through the revetment on the scarp side, the water then instead of spouting out over the high bank falls upon the rock, and escapes more easily.

Tanks or Reservoirs for irrigation.

16. Supplementary to the direct works on the Beejapoor Water-course, the adaptation of numerous old tanks as reservoirs for irrigation was determined on. Of these there were 27 on the high land between the Bindal, Asun and Tonse rivers, but the whole of these were more or less in ruins. These tanks were constructed at a former period, by throwing up embankments in the form of a loop with the side towards the natural drainage open. I have before explained the liability to accident of the water-course

in its passage under Purotewalla : such accident might entirely cut off the supply, and deprive the cultivators of the means of irrigation at the very time when water was most required. It was desirable therefore to make the Zumeendars independent of such a serious contingency, and as the whole of the supply in the water-course was never totally absorbed in irrigation, that all spare water should be thrown into the tanks abovementioned, that these tanks should be kept constantly full, so that in the event of any accident happening to the main channel, or even in extraordinary demands for irrigation, a certain supply should be secured, and the cultivators should have the means of irrigating their lands until the accident had been repaired, and water re-admitted. The European farmer would naturally maintain his tanks, and keep a supply of water in his own hands without trusting blindly and entirely to the water-course, which *must* be liable to occasional interruption; it would require on the contrary, some management to make the native Zumeendars do the same, and it would therefore be necessary to lay down rules for the maintenance of these tanks, to insist on their being kept filled at all seasons, and to make the Canal Establishment answerable for any neglect in seeing these arrangements carried into effect. There can be no doubt that the tank system is an admirable auxiliary to the project not only in offering a provision for irrigation, but also for watering cattle, bathing, &c.

17. The tanks in question merely required repair to their embankments, a regulating sluice drain for the distribution of the water, and a cut from the nearest branch of irrigation for the supply.

18. Three of these reservoirs have been completed, viz. at Meetaburri, Kaonli and Ismutnuggur; their value however, has not up to this time been properly tested; it is intended to complete the whole, or as many of them as may be necessary for the demand.

Absorbent quality of soil on the tract under the influence of the Beejapore Water-course.

19. Owing to the absorbent quality of the soil through which the Beejapoor Water-course runs, the loss of water by percolation is very great, this is an evil to which the tanks are more or less subject, and must be provided against by puddling, and establishing clay bottoms and sides. I have no doubt that eventually when the value of water is properly appreciated, and when cultivation extends over the whole tract which comes under the influence of the water-course, it will become advisable to continue the masonry channel from Dhakra, at which place it now terminates to its junction with the Asun river—the cost of a channel of this description with a water-way of 3 feet wide by 2 feet deep, would not cost more than 5500 rupees per mile—an outlay which would be literally of no consideration in comparison to the present loss of water, supposing that the water now lost was required by the cultivators.

Corn mills.

20. Mills for grinding corn have been already built at various places on the line of water-course, and others are in progress of construction—these mills are rented out to farmers who pay so much per day or year to the Canal Treasury. The returns on this item have been up to this time more satisfactory than those on land irrigated, as will be seen by reference to Appendix C.

Plantations.

21. The sum of 200 rupees a year is placed at the disposal of the Executive Officer, for the purpose of planting trees on the outer side of the water-course banks. The plantations commenced in the rains of 1843 and are now in progress; in addition to the Toon, Sirrus and other useful trees which grow so well in the plains—the plantations will comprize the Deodar, Cherry and other trees, which appear to thrive well in the valley of Deyra.

22. The works of the Beejapoor Water-course were constructed under the management of Captain Henry Kirke, at that time

Adjutant to the Sirmoor Battalion, they were commenced in October 1839, and water was admitted on the 8th of January 1841, rather too late for the cold weather crop or Rubbee in 1840-41. There is a want of finish, and a want of extreme accuracy in the uniformity of levels of this work which might have been prevented, but the stability of the masonry channel on the precipices under Purotewalla is the best proof of its soundness; only two accidents have happened on this line during the five rainy seasons that it has undergone, viz. one rising from the falling of an enormous mass of shingle, which carried away the channel with which it came in contact, and the other from the failure of an arched aqueduct crossing a ravine during the rains of 1844—arising I believe from a rapid collection of water during an unusually heavy fall of rain which undermined one of the revetments. When it is recollected, that many portions between the head and Purotewalla, which for the sake of economy had been estimated for as plain earthen channels, had been constructed of masonry with a channel of 5 feet wide, a width that was continued on the whole line; besides numerous improvements which suggested themselves in the progress of the work, the Beejapoor Water-course does Capt. Kirke great credit, especially in the economical outlay of funds, which under all the unforeseen difficulties of the undertaking only amounted to Rs. 15,926-14-7, or about 14 per cent. on the amount authorized by Government.

Rajpoor Water-course.

23. The Beejapoor Water-course having been completed, my attention was directed to the Rajpoor Water-course, and to the following para. from Mr. H. S. Boulderson's* Report on the Deyra Doon, dated 12th October 1839:—

Para. 66. "Next to roads, the most public work in the Doon 'is the Kool or small Canal which brings water from the foot of

* Commissioner 1st or Meerut Division.

'the hills at Rajpoor, to the town of Deyra, about 7½ miles—from 'this a large pucka tank of old date is filled. The other sources 'of supply are only two wells of great depth, one of old date and 'one constructed under the superintendence of the Hon'ble Mr. 'Shore by the British Government. These furnish the only good 'drinking water; the water of the Canal is perfectly wholesome and 'good at its head, but the accumulation of filth, leaves, earth, &c. 'in its course, even though cleared out twice or thrice a year, 'renders it of unwholesome quality. Evaporation and absorption 'greatly reduce its quantity, so that it is insufficient frequently in 'the warm months; and as the banks frequently break in the rains 'it is for several days occasionally stopped. I would recommend 'that this water-course be made pucka, for which the cheapness 'of lime and the plenty of stones and ease with which bricks can 'be made and burnt, offer great facilities, the work would not I 'conceive cost more than 8 to 12,000 rupees, including proper 'sluices and overfalls. At present the inhabitants of Deyra, 'Native and European, do not pay any thing for the water, and 'there are a number of flour mills along the Canal turned by the 'water, a tax or charge for the water at the rate of two annas per 'foot frontage* of compound per annum on Natives and Euro-'peans for water for domestic purposes, and of 12 rupees per 'annum on each mill, would yield a very remunerative return for 'the outlay: any water allowed for irrigation should be charged 'for separately, but as this could not always be afforded, the 'authorities should always have the power of entirely preventing 'any abstraction of the water for this purpose."

24. The above para. will explain the main object which was in view in improving the Rajpoor water-course, viz. to economise the water, and to deliver it in the town of Deyra, pure and wholesome for both drinking and culinary purposes.

* Frontage not merely to, or on the Canal, but to the road or street in which the principal entrance of house or compound may be.

History of the ancient Rajpoor Water-course.

25. The history of this work and its original foundation is not very distinctly explained, but it is probably one of considerable antiquity, and coeval with the establishments of Deyra as the capital of the valley, or of the Seikh temple as the chief residence of the High Priest. The Mohunt or High Priest, into whose tank the tail water falls, describes it as having been dug by his forefathers; and it appears that this family did formerly keep it in repair and levy taxes on mills, &c., which were benefitted by it. I have no doubt that previously to our taking possession of the valley, when the power of the Mohunt and the influence of his authority were of greater weight than they now are, the water-course in question was maintained in an efficient state, and that some sort of supervision was given, to prevent the irregular establishment of mills and outlets for irrigation, as well as to keep up a sufficient supply of water for the inhabitants of the town: as the Mohunt's power gradually declined so the water-course went to decay, and on Mr. Shore's assuming charge of the civil duties at Deyra, he found it necessary to take the management of the line into his own hands, so as to secure a supply of water to the town; Mr. Shore appears to have taken much interest in the work, as is shewn by numerous bridges, aqueducts, and a terminating reservoir conveniently raised near the parade of the Sirmoor Battalion. Mr. Shore's arguments for the necessity of authoritative interference, will be best explained in his own words addressed to the Secretary to Government in a letter, dated June 16, 1827 :—

" If it (the Rajpoor water-course) be not put under some au-
' thority as hitherto has been the case, there will be repeated
' complaints arising from the attempts of individuals to take the
' most for themselves, without caring how their neighbours suffer.
' The Mohunt of the Seikh temple claims water to irrigate his
' fields on the plea that the founder of the temple dug the aque-
' duct to supply the temple tanks. The villagers along the banks

'claim the same, saying that the person who dug the aqueduct, 'only gave a small part of the expense, and that their ancestors 'supplied the rest by giving free labor, both which statements are 'true. The officers and men (a great many of the Native Offi- 'cers and Privates had small gardens till the late repairs, when 'they were given to understand that if they watered them they 'must pay for it) of the Sirmoor Battalion, claimed the water on 'the plea of being the strongest party; in short, every one will 'consider himself as free to do as he pleases; the villagers higher 'up will draw off the water to irrigate their fields: men will be 'sent up from the Battalion to prevent it, and then there will be 'a quarrel and most likely an assault. Whilst the town of Deyra 'which is below the lines, will have no supply, but the muddy 'refuse of their tanks which will get filled in the rains."

In a letter dated 25th May, 1826, Government appears to have authorized Mr. Shore, to disburse the sum of 954 rupees in repairing the water-course, and to levy a cess as proposed by that gentleman of one rupee for each mill driven by it, and three rupees for each beegah of land irrigated with its water. On the departure of Mr. Shore the management of this water-course was taken by Colonel Fred. Young, the Political Agent and Commandant of the Sirmoor Battalion. I believe that both the maintenance of the bund at its head and the repairs of the water-course itself, were during this period effected solely by the aid of the men of the Battalion, unassisted by funds from the State: and the revenue derivable from mills and irrigation was foregone.

26. It will be understood from what has been before said, that with the exception of the wells alluded to in Mr. Boulderson's Report, the inhabitants of Deyra depend solely on the supply of water in the water-course for drinking purposes, that the object of the Mohunt, Mr. Shore and Colonel Young, had been confined solely to the maintenance of the line for this special purpose, and that it had not been considered necessary to take a greater supply of water from

the head than the demand for the inhabitants of the town required

Description of the Ruspunna River.

27. The Ruspunna river which supplies water to the Rajpoor water-course, is similar in character to the Tonse described in para. 11, its stream is perennial under the town of Rajpoor, and for some miles south, but during the dry months the water in advance sinks into the bed of the river, and only re-appears at spring heads near its junction with the Sooswa river.

Description of the ancient Rajpoor Water-course.

28. The ancient Rajpoor water-course left the Ruspunna at a point about 2 miles south of Rajpoor, and somewhat north of the village of Kishnpoor, the early part of its course is through rice fields and flat land lying on the right bank of the Ruspunna river, and its access to the high land is obtained under difficulties of no extent whatever when compared with those at the Beejapoor water-course, it had no branches, and terminated in the Mohunt's tank.

Estimate for the improved Rajpoor Water-course. Submitted November 1840.

29. My plans and estimates for the improvement of this work were submitted in November 1840. The project combined both the supply of water for drinking purposes to the town of Deyra, and for the irrigation to the country bounded by the Ruspunna, Bindal, and Sooswa, it was in fact giving the benefits of water to another triangular patch of land lying to the east, as the Beejapoor water-course did to that of a similarly outlined tract of country on the west of the Bindal river. The proposed water-course was to consist of a masonry channel extending from the Ruspunna above Kishnpoor to the Mohunt's tank in the town of Deyra, with an excavated channel for irrigation branching off from a point at the north of the Cantonment. and extending over the high land by the village of Dhurumpoor: the masonry channel in the earlier part of its course was to have a slope of bed of 18 inches per 100 feet, and the lower portion 15 inches per

100 feet in length, the excess beyond this to be overcome by masonry descents: the branch line for irrigation was to be on one uniform slope of 1 inch in every 100 feet, with the excess conquered by masonry descents similar to those on the main line—10 mills for grinding corn were also recommended, and the total amount of the estimate was Rs. 41,208-2-0.

Cost of the Rajpoor Water-course.

30. The authority of Government having been given for the commencement of the work, and Captain Kirke having been placed at my disposal temporarily for the purpose of superintending its execution—the water-course was commenced in the cold weather of 1841, it was completed, and water admitted early in the rains of 1844—there was some delay in the progress of operations, partly owing to unforeseen contingencies and partly to Captain Kirke having been ordered with his Regiment to Bareilli, during which absence the work was entirely stopped—the total outlay exceeded the estimate in a small degree, the cost being Rs. 42,984-11-9.

Maintenance of the old, during the construction of the new Rajpoor Water-course, with the general description of the works.

31. The necessity that existed of maintaining a supply of drinking water for the town of Deyra during the operations on the masonry channel, led to some inconvenience, and to the adoption of an alignment for the new channel, generally speaking quite distinct from the old kool or water-course—the old line crept along the side of a bank on nearly its whole course to the high land, the bank acting on one side in retaining the water; it was therefore decided that the new work should be carried in straight lines across the valley, quite independent of the old kool, and where interference did from necessity take place, that temporary arrangements should be made to prevent interruption to the flow of water towards the town; by this plan the old line could not only be made use of during the progress of the new work, but it would be valuable hereafter as a catch drain to the drainage of the high land, and its escapes might be regulated, and

water collected at points where preparations had been made to receive it—the arrangements made by Captain Kirke for this part of the work were exceedingly good, the supply of water to the town of Deyra was never in one single instance interfered with, and the alignment of the masonry channel has been managed very satisfactorily; this channel is raised at many places to a considerable elevation above the country over which it passes; both the upper and under-drainage has been carefully attended to between Kishnpoor and Jakhun, a tunnel of 100 feet in length has been carried through a ridge; and it has been pierced at eighteen different points to admit of free under-drainage to the country; at a point near Kishnpoor, the channel is supported on 37 arches, near Mookundwala by 17, and at other places by arches varying in number from 1 to 11. Boulders from the bed of the Ruspunna river, and from the neighbourhood of the work have been extensively used in its construction, especially in the floorings and solid portions; of the foundations; the parapets or retaining walls are built entirely of brick, with stone work at places where grooves are required for sluices. The main channel which is in width 4 feet and in depth 18 inches, continues from the head to a point near the gateway of Captain Kirke's Estate at Deyra—from hence it is divided into two branches, one of masonry with a channel 2 feet wide and 18 inches deep, which is carried to the Mohunt's tank in the town—and the other an excavated channel, as before explained for the irrigation of the lands at Dhurrumpoor, &c. At the point where these branches separate, a reservoir is established for the purposes of regulating the supply of water to each branch. The raised reservoir near the lines of the Sirmoor Battalion, referred to in para. 25, has been enlarged and improved, and a lower octagonal basin for the reception of the water which passes from the upper levels, has been connected to the original design, by a raised terrace on which is a fountain or jet, which during the hot months of the year, or even at any period, may be made very ornamental—the

neighbourhood of these reservoirs has been planted with trees and if they are taken care of and dirt and filth prohibited in the proximity of the water-course—the quality of the water for drinking purposes ought to give satisfaction. Besides those abovementioned, other masonry reservoirs have been built in the town, for the convenience of the people.

32. The slopes of the channels are as described in para. 29, but the actual slope of country as shewn by my original survey, will be best explained as follows :—

	Distance in Feet.	Fall in Feet.	Slope per 100 Feet.		
			feet.	ft.	in.
From the Head north of Kishnpoor to the high land and departure of the Dhurrumpoor branch, ...	18261	346·0	1·89	or 1	10¾
From high land to Mr. Shore's Reservoir near the Sirmoor Battalion Parade,	7083	117·17	1·65	or 1	7¾
From Reservoir to Mohunt's Tank, ..	4760	69·84	1·46	or 1	5½
From the departure of the branch to Dhurrumpoor to end of branch, ...	17315	243·38	1·40	or 1	4⅝

Troughs and Tanks.

33. Troughs and tanks have been constructed at different points on the line, for cattle to obtain drinking water from, and to secure the main channel from the filth and dirt which otherwise would add impurities to the water. Many of these tanks are now under construction. The Chokidars ought to be made to pay attention to the state of these works, especially to those designed for washing cattle—the ground in their vicinity would be greatly improved by a pavement of boulders (which are in abundance everywhere,) well rammed down, without cement, an arrangement which would keep the tanks tidy, and put a stop to the pools of water and mud that must otherwise occur. The state of the floorings must also be watched, as well as that of the inlet and escape for the water.

Corn and other Mills.

34. Ten mills for grinding corn have been established, and others are under construction; near the village of Dhurrumpoor, a circular saw-mill will shortly be fixed, the building is far advanced and the

machinery is ready, the situation in which it is placed is very favorable as far as timber is concerned, the village of Dhurrumpoor being the mart of the greater part of the Saul wood which is cut in the forests of the eastern Doon, but being at the tail end of a water-course, it is probable that the mill may be interrupted by want of water, when the demands for irrigation are very great; Capt. Kirke however tells me that he does not anticipate any contingency of that sort and the situation is in other respects so very desirable, that even with occasional interruptions it may be considered preferable. The saw machinery which is about to be established at Dhurrumpoor, was formerly procured for the use of the Delhi Canal, but was never I believe fixed, it is a very appropriate addition to the works on the Doon water-courses, where the water-power is so extensive, and where it is naturally an object, to shew to the native community the different methods by which this power may be taken advantage of.

Plantations.

35. An annual allowance of 200 Rs. is authorised for plantations on the Rajpoor water-course—they were commenced in 1843 at the same time as those on the Beejapoor line ; they are not far advanced at present, being chiefly confined to the Dhurrumpoor branch, the right bank of which is a broad road connecting the cantonment with the village, and completing a circular drive which has added greatly to the improvement of Deyra.

Supply of water and capabilities of the Ruspunna as a feeder.

36. In October 1840, when I measured the discharge of the Ruspunna at the point where the water-course leaves it, there were 28 cubic feet per second available, (7 of which only were passing down the water-course,) and it was calculated that this would be reduced in the dry months at least one-half, leaving a discharge of only 14 cubic feet per second in the river. In December 1844, the measured discharge in the main channel of the newly constructed water-course above its separation into two

branches, was 18·4 cubic feet per second, the depth of water being 6·3 inches with a superficial velocity of current of 11·79 feet per second; at this time the whole of the water in the Ruspunna was passing down the water-course—the bund at the head being thrown completely across the river, the supply of this river however is variable, and dependent in a great degree on the demand for water for irrigation in the mountains above its debouche under Rajpoor, on the utter want of economy in which the water is used by the native cultivators for irrigation, and on the carelessness with which the courses to the native corn-mills are constructed. One great cause of this interruption to the supply will shortly be entirely removed, in getting rid of numerous corn-mills which have, since the establishment of Mussoori and Landour, been gradually collecting under the town of Rajpoor, at a point situated about two miles *above* the head of the water-course. I have before referred to the absorbent quality of the soil in the Doon; it may therefore not require much explanation to shew that the numerous branch cuts and tail escapes made for these mills, together with the excessive carelessness of the millers in letting the water flow over the ground in inundation, tended greatly to diminish the volume in the Ruspunna on its reaching the water-course head: moreover, as one of the main objects in projecting the Rajpoor water-course as a line of masonry aqueduct, was to prevent the water from being charged with impurities from the carelessness of millers in deserting their works, and leaving the escapes to be carried away, it was determined that proper economy should be practised in the use of the water under Rajpoor, and to effect this, that compact sets of corn-mills should be built, supplied by one masonry channel, so as to preclude all wastage as well as wear and tear of earthwork. Eight of these mills are nearly completed, they occupy a flat on the right side of the river, which is out of the reach of high flood, and will most effectually do away with the evil before

Rajpoor Corn-Mills.

complained of; should more mills be required there is ample space for them on another spot somewhat lower down the course of the river, of which the levels were taken by me for the purpose of testing its capabilities.* When the Rajpoor mills are in use, and the present native ones abolished, I anticipate a greater and a more regular supply to the water-course; but it would still further add to its improvement and efficiency, if the Civil Superintendent of the Doon would insist on the kools or water-courses of villages, situated above the mills being properly made, and visit with his displeasure all wanton waste in useless inundations; the village on the left bank of the Ruspunna immediately above the site of the Rajpoor mills, has it in its power most completely to injure their interests by taking water off from the main channel, and turning it back again at a point below the mill-dam, and the carelessness of the natives is such, that to save themselves from the trouble of closing their water-course heads, they will, if under no proper control, take no sort of interest in the disposal of the water, after their immediate wants are satisfied; I think that the name of this village is Undhoiwala; the above cirumstance however has been explained by me to Mr. Vansittart, the present Superintendent, who has always shown himself most desirous of attending to the interests of the public works in his district.

37. The excessive velocity of the current in the main masonry channel of the Rajpoor water-course, which I have described as due to a slope of 18 inches per 100 feet, has led to a circumstance which I confess that I did not take into consideration when projecting the work, viz. the probability in high floods in the

* I would recommend that no time should be lost in making a good carriage road to the mills, 18 feet wide on a slope not exceeding 5 feet per 100. I am not sure that this road from Deyra and the plains might not commence from the foot of the Rajpoor Hill near Mr. Jones' Hotel, by which both ascent and descent would be avoided—from the mills another road should be made to join the high Mussoori Road near the Isthmus. These lines however, ought to be properly surveyed before they are commenced upon.

Ruspunna of the introduction of large boulders into the masonry channel, and the facility with which they would, owing to the velocity, be rolled along its course, doing injury to the terrace, and at the falls affecting the masonry work; this was first shewn during the rains of 1843, when a portion of the bank of the old water-course, which consisted chiefly of stone, fell into the masonry channel during a very heavy fall of rain, these stones were urged on by the current until they found an escape at an outlet, but the terrace was injured on a distance of many hundred feet—to prevent a recurrence of a similar accident, iron gratings were fixed across the channel at certain distances, so as to stop the larger class of boulders, and prevent injury to the masonry; these gratings, however efficient they may be in preventing the advance of stone, act awkwardly, opposed to such a rapid current: and the position of a number of them close at the heads of falls was not the most judicious: the results of the late rains have shewn that some more effectual remedy must be adopted, in either establishing reservoirs or traps near the head, on purpose to catch the stone, or else by reducing the declivity of the bed of the channel on the first few hundred feet of its course, take away the power of rapid movement; arrangements were in progress for constructing traps on my resigning charge of the works: the smaller class of shingle would in any case, I imagine, find its way down the channel, and it is strange to observe, that although the water to all appearance is as clear as crystal, the basins and regulating reservoirs require periodical clearance from a coarse blue sand, that is borne along in the stream; the same occurs in the Beejapoor water-course, where the water is in appearance equally clear.

38. As the water-course has only been in action for a portion of one rainy season, it is not yet certain whether the Ruspunna supply during that season is discolored by the admixture of earthy matter, or whether this only takes place during heavy floods. I believe that this only

Purity of water during the rains.

occurs occasionally, but should it be objected to, a filtering apparatus might be made at a very trifling expense, so as to deliver water to the town without interruption, in a perfect state of purity.

39. For the convenience of taking water for drinking purposes from the main channel, small reservoirs ought to be built on the right and left at fixed distances. A plan of a set of these has been forwarded to the Executive Officer; a circle or square of two feet internal diameter, would be sufficient to admit of a gurha or lota; the depth of water to render it useful for the purpose intended must be at least 18 inches.

Suggestions for arching over the water-course in certain positions.

40. At some points in the town the water-course runs at the back of the street, in a situation where dirt and filth appear to be thrown; at one or two points this has been remedied by arching the channel over, and this ought to be done universally, where there is the least chance of the water being dirtied; there are some points also where the channel is considerably below the surface of the ground with garden land in its neighbourhood—here also by arching over the water-course, the garden might be restored to its original state and the whole surface now occupied by the open channel might be cultivated. In all this tunnel work however ventilators or wells ought to be constructed at each 30 feet in length of tunnel, and the arch ought to be sufficiently capacious to admit of internal repair. The tunnel between Kishnpoor and Jakhun would be much improved by being extended on the south side, where the banks are very high.

Natives of the town of Deyra inclined to improvements.

41. There appears to be no want of inclination amongst the inhabitants of the town to make improvements, judging not only from the masonry channel attached to this water-course built by the Mohunt, and also from some works of minor importance, but from the shops and buildings erecting under the advice and recommendation of Mr. Vansittart, the Superintendent of the

Doon. The excessive declivity upon which the water-course runs, offers every facility for the introduction of fresh water into the private buildings in the town, tanks and fountains might be constructed, means of watering streets and supplies of water in the case of fire, might be provided in every part of the town of Deyra; and I cannot but hope that some well organised system of improvement on all these points may be carried out, so as to prove to Government that the outlay on this work is duly appreciated. A suggestion of mine, which probably from want of funds was not acted upon, would have been a very great improvement, and even had it been commenced upon and completed by degrees, would have ultimately been a convenient as well as an ornamental addition to Deyra; many shops which might have come into this arrangement are now built elsewhere in different points of the town; the design therefore of a bazar as recommended, which was to consist of a spacious octagon, one face of which was to be formed by the Seikh temple, may be merely mentioned here as a record, in the event of future improvements of this sort being contemplated.

Octagonal Bazaar proposed at Deyra.

42. The Seikh temple is situated on the Saharunpoor side of the town, with a great deal of open space to the east or front; with the exception of one or two small masonry buildings, an area equal to that of the proposed octagon would have been secured, by the removal of grass huts merely, and there appeared to be no difficulties in obtaining the ground, the only person who offered any objection being an European resident, whose estate would have been infringed upon in a slight degree: the octagon was in fact lined out and opportunities given of seeing how far and to what extent it encroached upon property. The design was to make the high road to Saharunpoor enter the octagon on its southern face through a gateway, with a corresponding gate on its opposite side adjoining the town—this octagonal enclosure was to

be surrounded by shops, in the style usually adopted in the cities of India—the internal area would have been cleared, and in the centre and immediately opposite the Seikh temple, a fountain would have been situated, the jet of which was proposed to be 30 feet in height. The alignment of the road both of approach and exit was in every way favorable to the features of the existing streets, and the enclosure would have formed a handsome approach to the town from the Saharunpoor side. With reference however to improvements or additions made to the water-course by private individuals, nothing ought to be done without the supervision of the Executive Officer, so that a perfect uniformity of design may be preserved throughout the whole work.

Mr. Mackinnon's plan for a water-course to the town of Rajpoor.

43. Considering that the "Rajpoor Water-course" is totally unconnected with the town of that name, it ought properly to have been designated the "Deyra Water-course," and another line taken for the purposes of the town of Rajpoor, would more naturally have assumed the former title. Retaining however the name of the Rajpoor water-course as it has always been called, it would have been a difficult and a very expensive project to have removed the head to a point sufficiently high on the Ruspunna river, to admit of the stream passing through the town of Rajpoor. The site of a head for that purpose would have been near the village of Undhoiwala referred to in para. 36; the direction of the line would have skirted the steep slopes of the mountains, some of which consist of a loose fragmentary and friable rock, which would have offered great impediments to the establishment of a masonry channel, of the capacity required; after reaching the town the line would have had to continue on the narrow ridge running between the Ruspunna valley and the Bindal ravine; at some places so narrow as to be entirely occupied by the road; the slope especially near Rajpoor would have been enormous, and the expense dependent on numerous masonry works, would not in my

opinion have been repaid by the advantages offered either in irrigation or other purposes. The town of Rajpoor, which in my recollection was a mere hamlet consisting of a few huts, has now in consequence of its situation relatively to Mussoori and Landour, become a place of some importance—its population is annually increasing, and the wealth of its inhabitants would, I have no doubt, tend to improvements, if assisted by the co-operation of the proper authorities.* The whole of the water used for drinking and domestic purposes in the town is brought from the Ruspunna river, which is situated at a considerable distance below in a deep valley. Mr. Mackinnon, the worthy and excellent founder of that admirable institution the "Mussoori Seminary," who has interested himself so much in improvements and has latterly placed the community under still greater obligations to him, by laying out a road from Rajpoor to Mussoori on approved scientific principles, has proposed that a water-course should be made for the supply of Rajpoor, from the point at Undhoiwala before mentioned. I see no obstructions to the project—the difficulties before alluded to, arise from the magnitude of the channel required to be constructed round these dangerous slopes, and would not exist with the small supply demanded for the drinking purposes of Rajpoor—this supply would I imagine be most economically (as well as with the least interruption) obtained by pipes, until the difficulties of the slopes were passed, after which the water would proceed through the town in a small masonry channel 18 inches wide and 15 inches deep; and be carried in this way for about five miles until it reached the present Rajpoor water-course, into which the tail water could fall; this I look upon as necessary to the project, for the supply

* They can't be in better hands than those of the present Superintendent of the Doon, who has done much, and will do more for the improvement of this beautiful valley.

taken *for* the new water-course, would be so much taken *from* the old one. In the passage through Rajpoor and down the country, reservoirs might be established for drinking purposes, and small as the body of water might be, the declivity is so great, that overshot wheels of any diameter could be fixed on the line. Saw-mills might be established at the timber marts at the foot of the Rajpoor hill, and I have no doubt that a fair return would be obtained for the outlay; irrigation also to a limited extent might be practised, and vegetable gardens and mango plantations would add much to the improvements of the suburbs of the rising town of Rajpoor. I have no data for estimating the cost of laying down pipes; but supposing that this part of the work could be done for 3,000 rupees, and the water be delivered on the high land at Rajpoor, the total expense of delivering the tail water into the Rajpoor water-course, north of the Cantonments of Deyra, would be thus, in approximation:—

Piping supposed to be, ...	Rs.	3,000	0 0
Five miles of masonry channel, 18 inches wide and 15 inches deep, at 4000 rupees per mile, . .	„	20,000	0 0
Ten Reservoirs, 2 per mile, ...	„	2,000	0 0
Total cost, Rs.		25,000	0 0

By turning the tail water into the Rajpoor water-course at Jakhun, half the expense of the second item might be saved. I have no reason for doubting that for an expense averaging from 15 to 25,000 rupees, Mr. Mackinnon's plan might be satisfactorily accomplished.

Kuttha Puthur Water-course. Estimates submitted April 1841.

44. During the cold weather of 1840-41, the survey of the Kuttha Puthur water-course was undertaken by me—and plan and estimates submitted, the latter amounting to 90,307 rupees.

The times were not favorable to undertaking works of this sort, and the project, although printed in the "Journal of the Asiatic Society" for record, was abandoned.

Object in recommending the above.

45. The object of this line was to irrigate the tract in the western Doon, bounded by the Jumna river and the Sutwala Rao on the west and east, and the forests of Umbarri and Pirthipoor, and the Asun river on the north and south; the return of village lands which accompanied my Report, shewed that about 17,000 acres of cultivable land would be benefitted by the work; the tract consists of open grass land with little forest, merely requiring water and population to render it, with the smallest imaginable labor, a richly cultivated country. Here (as in every other part of the Doon where water-courses have been constructed) the introduction of water for drinking and domestic purposes, would alone be highly prized; in the tract of country alluded to, I believe that Pirthipoor is the only village in which a well is to be found, and the supply from that well is barely sufficient for the purposes of the village; it is not therefore for irrigation merely that the construction of the Kuttha Puthur water-course was advocated, but as the means of introducing upon an extended surface of a thinly populated country, an element without which neither population would increase, nor could the settlement of villages be extended. Captain William Brown, of the Revenue Survey, whose maps of the Deyra Doon are now before me, referred in his Report, to the possibility of watering the high land in question, from a point on the Jumna near Dumaiyut, and my attention was directly called to the subject by an application from the firm of Maxwell, McGregor and Co., who held a large grant of land on the Jumna, called Innisphael, of 7,462 acres in extent, and another tract called Hopeton of 7,894 acres, both of which would have come under the influence of the water-course. The firm was unable to advance funds sufficient for the work, but seemed in-

clined to enter into contracts for the water required for their property. As a matter of speculation the return for outlay would be sufficient to warrant an expenditure, in the first instance, equal to the amount of the estimate, and as Government had in a former occasion established a precedent, in preferring that a work of this sort, which must ultimately be of service to numerous parties, should be managed by its own officers and kept under its own control, instead of becoming the property of a private individual or firm, the Kuttha Puthur water-course appeared to offer fresh means for extending this precedent, in not only improving a large portion of the Doon, which without water could not be improved, but in disseminating its benefits equally throughout eleven different estates.

Description of Kuttha Puthur water-course.

46. The character of this work corresponds in some degree with the Beejapoor water-course, but the difficulties to be contended with are greater. The Beejapoor line after leaving the Tonse, reaches and passes over the high ground without any interruption in its course from mountain torrents, whereas, that now about to be described after overcoming the banks of the Jumna, in which it passes numerous streams, proceeds over the high land, crossing the drainage at right angles, until it falls into the bed of the Sutwala Rao, a river (similar to those before described having a wide bed of shingle, and only carrying water during floods,) which joins the Asun river near the village of Kooshialpoor. The point fixed upon by Captain Brown at Dumaiyut, was found to be impracticable, from the steppes into the Jumna from the high land being exceedingly steep, and from the relative level of the river being low at that point, full advantage of slope was not attainable. The head which I determined on therefore is much higher up the course of the Jumna, at a point immediately under the village of Kuttha-Putlur, this head is favorably situated for a supply of water, and as the depth of excavation at the point where the

water-course would leave the river was designed at three feet, the annual expenses on spurs and bunds would be trifling. Without entering into detail, which may be found in the original Report, it will be sufficient to give a general idea of the work, and the country over which it passes. For the first 4,755 feet of its course, the channel would proceed over tolerably even and in parts somewhat low ground, and would cross two mountain torrents, one of which would be passed by a dam with ten sluices, and the other of two sluices of ten feet each—the beds of these rivers consist of boulders and large shingle, which would add to the facilities of constructing the works, and render them little liable to accident when built. The form of dams would be similar to that practised on the Jumna Canals. In advance and on a line measuring 18,916 feet, the water-course would creep along the slopes and scarps of the left bank of the Jumna, until it reached the high land, the slope of bed proposed for the channel is 24 inches per mile. On the abovementioned distance four mountain streams are passed by aqueducts, two of which have a span of 50, one of 40, and one of 25 feet; the whole or the greater part of the channel on this length, (extending nearly three miles) would require to be built of masonry, and it is probable that, as was the case in carrying out the project of the Beejapoor water-course, it might be found better and ultimately cheaper, to make the whole, line from the head to the high ground, of masonry. The distance from the top of the high land to the Sutwala Rao is 21,834 feet, and is intended to be of simple excavation: six lines of drainage are passed on this section, two of which are to be crossed by aqueducts of 25 feet span each, and four by dams, one of which has 10 sluices of 10 feet wide each, and three have one sluice each 10 feet in width. The slope of bed is to be continued as before at 24 inches per mile, and the fall which is in addition to this is to be passed by four descents of masonry, one of $4\frac{1}{2}$, two of 8 and one of 12 feet, the latter one delivers the stream into the bed of the Sut-

wala, and ultimately into the Asun and Jumna rivers. The direction of this water-course has been projected parallel and close to the high and broken ground of the Pirthipoor forest, so that as much country as possible should be benefitted by its waters.

47. The supply of water required for this irrigation was 80 cubic feet per second, and the internal dimensions of the masonry channel were proposed to be 10 feet wide by 4 feet deep, the land which would come under irrigation lies almost entirely on its right bank, on a rapid slope, and favorably in every way for the supply to the cultivators. The masonry falls give the means of turning the water to account in machinery, and my estimate included the cost of two corn-mills at Pirthipoor. Although the project terminated in the bed of the Sutwala Rao, the water might be carried across the bed of that river, by either temporary bunds or troughs, in which case an additional tract of at least four square miles would be benefitted.

Supply of water required for the Kuttha Puthur water-course.

48. I hope that many years will not elapse before this work is carried into execution, the cost is greater than that of either the Rajpoor or Beejapoor water-courses, but the difficulties are greater, and the work itself is more extensive, not only in its conponent parts, but in the surface of country which will come under its influence; it cannot be too often repeated, moreover, that the want of drinking water that exists prevents the establishment of villages at points, much elevated or distant from the perennial streams in the Doon, and the want of population depending on this circumstance will, until canals are made, interfere altogether with the improvement not only of the tract alluded to, but of other portions similarly situated.

Marshes.

49. 'At a period when European settlers had commenced farming in the Doon, and when it was anticipated that the offers held

out by the Government, would lead numerous individuals to establish themselves in different parts of the valley; when Europeans had in fact settled themselves not only centrically, but also on the Jumna and Ganges, it become a matter of consideration how far the clearance and drainage of the extensive marsh lands that existed, especially in the eastern Doon, might add to the salubrity of the climate, and by removing the tendency to fever and sickness which exists to a fearful extent during some portion of the year, give encouragement to Europeans to take possession of numerous tracts of land, rich in their own capabilities, but deadly from the unhealthiness of the climate. The characters of the eastern and western Doons differ essentially—the former may be considered as that of forest, whilst the latter is comparatively open grass land. I have in para. 3, noted that the eastern Doon is through the greater part of its extent traversed by two perennial streams, the Song and the Sooswa—these two rivers unite at a point west of Khurruk Shampoor, receiving in their course numerous small tributaries, as well as supplies from spring heads—to this excess of water is to be attributed the rankness of vegetation that displays itself in all this tract, where the open unwooded prairies of the western Doon are represented by extensive forests. Near the village of Jogiwalla, and at the junction of the Song and Sooswa, marshes and tracts of high grass and reed jungle exist to a considerable extent, and further eastward and on the approach of the Song to the Ganges, the low lands are intersected by a labyrinth of nullas and water-courses, some of which join the Song, and others the Ganges river under the village of Rayawalla.

50. The Jogiwalla marshes lie at the lower extremity of the Jakhun Rao, one of those lines of drainage which are dry in the hot months, but are liable to heavy freshes during the rains, at which period independently to their supply from natural streams, they are flooded and overcharged with water from the Jakhun

river. The marshes in question are in detached pieces, the largest may perhaps measure two miles in length by half a mile in width, they are connected with the Song river by small nullas running on the most tortuous course and choked up by vegetation. The largest marsh is, I believe, quite inaccessable in its central portion, the parts that I have visited consist of clumps (either a few feet apart or close together) of a gigantic reed, or as the natives call it "Nul," the said clumps rising out of stagnant, or to all appearance stagnant water. It is evident that as these marshes are in the vicinity of a river running on an enormous slope, a judicious application of ditches laid out with reference to the levels of the country, and the spring heads which feed the marsh, would relieve the Jogiwalla forest from one great cause of its present unhealthiness.

51. The marshes above described, are comparatively situated in the low lands of the valley, but there are others of much greater extent to the north-east of Khurruk, and between that place and Rikekhes, which are on high land; Captain Brown who surveyed this tract of country, notes in his map with reference to the Gosainwalla marsh, "low marshy ground easily drainable." From the forest of the Rambuha Nuddi, the approach to the Ganges is gained by two distinct steppes, the high land between them varying in width from 2 to 2½ miles, on this elevated piece of land is situated the Gosainwalla marsh, containing three square miles, or thereabouts, of swamp; there are also other smaller marshes with numerous little tortuous nullas connected with them, running sluggishly with their courses marked by the densest vegetation, and the most impracticable rattan jungle; below the second steppe is the true Khadir of the Ganges river, a portion of which is sufficiently elevated to admit of its being drained; on the steppe and immediately parallel to the Gosainwalla marsh, is another swamp of about 1½ miles long and ¼ of a mile broad, Captain Brown's note on this is similar to that on the Gosainwalla marsh. The Gosain-

walla marsh approaches within half a mile of the steppe into the Khadir, both it and the lower marsh are traversed by and connected with the Rambuha river; the facilities therefore for drainage are more remarkable than those at Jogiwalla: at the period when my remarks on these marshes were submitted, viz. in April 1842, an enterprizing European, of the name of Vaughan, had for some years been established at a spot overlooking the Khadir of the Ganges, and within 1½ miles of the Gosainwalla swamps. The inhabitants of 'The Endeavor Farm' as Mr. Vaughan designated his property, consisted of himself, wife and children, all of whom had suffered very severely from fevers and sickness; this establishment is now broken up, owing to the death of Mr. Vaughan, and it is not likely that successors will be found anxious to contend with the unhealthiness of this portion of the Doon.

52. In the Western Doon the only marsh of any importance that I am acquainted with is that near Synspoor, it was formerly much reduced in extent by the Zumeendars having, as I am informed by Colonel Young, in digging some ditches for boundary or other purposes, relieved this low tract from a considerable portion of its water. When I visited the marsh however at the end of 1844, it had much increased in extent, arising in all probability from the ditches having either been choked up or obliterated.

53. The recommendation that accompanied my Report on these marshes, was that 1,000, or 1,500 rupees per annum should be authorized for a period of five years for digging escape drains, and using other means if necessary for getting rid of these nuisances. As the 'Endeavor Farm' had been established, and as the Gosainwalla marsh which was in its neighbourhood offered greater facilities for drainage than others, I suggested that operations should be commenced there in preference to that at Jogiwalla: my views are not altered at all with regard to the value that would be derived from these improvements: whether the clearance of the valley and increase to cultivation is to be caused by settlements

radiating from Deyra, or whether as was the case formerly, detached grants similar to those at the 'Endeavor Farm' are taken up: the leading element to success is *healthiness of climate*, and neither the eastern nor the western Doon can ever be considered healthly, as long as they are encumbered by these detestable marshes. The character for unhealthiness of the eastern Doon arising from these causes is so notorious, that for many months of the year the road between Hurdwar and Deyra is closed, and the few people who inhabit the wretched little hamlets at Jamunkhatta, Luchiwalaf, Dooiwalla, &c., exhibit in their appearance the inhospitable nature of the climate. Were the fact known that Government had taken measures for ridding this tract from stagnant water, and thereby in a great measure exterminating the extensive reed jungles, which from the harbour that they offer for tigers and other brutes, are alone inimical to the object of the settler, the soil is so fruitful and the advantages for cultivation so great, that natives would in all probability, in losing sight of these evils, congregate in the eastern as they have already done in the western Doon.

Plan of operations for drainage for marshes in the eastern Doon, suggested.

54. The plan of operations which I proposed was as follows, considering that it was only during six months in the year when works could be carried on, owing to the unhealthiness of the country, during and immediately after the rains. A main channel on a slope of not less than 4 or 5 feet per mile, was to be excavated from the point at which the drainage would escape, as far into the marsh as possible, or as work people could advance, this main channel would in all probability during one season have reduced the extent of swamp; smaller and branch drains might then be dug ramifying into the heart of the marsh, and by these means the spring heads could be gradually reached, and if necessary be pierced by borers: stagnant water having been removed by these means, the gigantic reeds and grass to which I have before alluded, would be replaced by grass of a smaller des-

cription. The final operations would consist in clearing out the drains, and preventing them from being choked up afterwards—inattention to the latter, would lead ultimately to the restoration of the marsh in all its original deformity.

Advantages of the pass or road into the Doon at Hurdwar.

55. Another reason and by no means one the least worthy of attention, for depriving the eastern Doon of its unhealthiness is, that the easiest method of access to Deyra from the plains, is, indubitably through Hurdwar; at this point the Sewalik Hills are turned on their eastern extremity towards the Ganges, by a good even road with neither ascent nor descent; at all other points the entrance to the valley can only be obtained through the steep tortuous and dry beds of mountain torrents, consisting of boulders and large shingle which (to make the line passable for wheeled carriage) during the dry season are placed on one side, and are liable to disarrangement by the smallest flood; such are the Kheeri, Timli and Kans Rao passes. Were the eastern Doon healthy, the Hurdwar entrance would be acceptable to a large class of people who visit Deyra, and the thoroughfare extending through its whole length, would doubtless tend to an increase both in cultivation, as well as in population. After leaving Hurdwar and entering the valley, the old line of road runs to the west and making a circuit round the high land of the Motichoor Forest arrives at the Kans Rao Choki by the village of Jamunkhatta; a new road has been made since the British took possession of the Doon, which instead of keeping to the low land, by which both ascent and descent are avoided, winds up the valley of the Motichoor until it reaches the high crest of the mountain ridge, above the Kans Rao Choki, at which point it descends on a rapid and zigzag slope to the valley; this road has the advantage of being about 1½ or 2 miles shorter than the other, but it leads the line into all the difficulties of mountain pass, which has been so completely escaped in the passage round the Hills at Hurdwar. For

use and convenience the lower is in my opinion decidely the one to be maintained—it is at present a mere cart track, and requires to be re-modelled and reconstructed.

Facilities for Irrigation—Attic Grant Tanks, &c.

56. At Khurruk, Rayawala, &c. irrigation is carried on to a large extent by the cultivators, who take their water-courses off from the smaller streams that intersect the country, the operations for the drainage of the marsh-lands would naturally lead to an increase to the supply for irrigation. Both the Sohg, Sooswa and Asun, offer very great facilities for improvements in this way—and if the water is economized and Canals judiciously arranged, means of irrigation would be provided for the whole surface of the valley.

57. It is probable that an examination of the heads of the rivers on the northern slope would bring to light many capabilities for improvement, but where there was water enough for one village only, I should be disinclined to interfere further than in giving assistance in projecting a water-course. When the supply was sufficient for a larger tract of country, and where the interest of numerous villages had to be consulted, it would then be necessary to place the water-course on the same footing and under the same superintendence as those of Rajpoor and Beejapoor.

58. In the "Attic Grant," there is a supply of water in the upper part of the Soarna Rao, capable of being turned to much better account than it is at present, it might perhaps be carried *via* Baneespoor to the Mamoonwala tank, which is situated between the Chor Khala and the Soarna river. It is a great object in projecting these lines of water-courses, to connect them with tanks which appear in former days to have been largely used in all parts of the valley.

59. There are many patches of high land on the left bank of the Asun that might be supplied with water for irrigation, by kools taken from a higher point in the river; but when this cannot be effected, reservoirs might be formed so as to catch water during

the rainy months, and I see no reason why these should not be made sufficiently capacious to hold water for irrigation, as well as for drinking purposes, Mr. Vansittart has paid considerable attention to this point, and has not only repaired ancient, but dug new tanks at numerous places in this district.*

60. In the eastern Doon there is ample field for improvement, not only in laying out lines of irrigation, but of getting rid of its superfluous water. The heads of the Song and other rivers ought to be carefully examined. A cut has, I believe, been made by Mr Vansittart from a point on the Song, eastward of the Kullunga ridge, which supplies the villages of Raipoor, Meeanwala, Hurrawala, &c. and ultimately falls into a tank. In the north-east angle of the eastern Doon there appears to be a field for extending irrigation, in taking possession of the water which exists in the early part of the course of the Jakhun river. Mr. Vansittart in his letter addressed to me dated 7th April 1843, thus describes the line in question—"The forest below Bhogpoor and Bussuntpoor 'bearing the name of Ranee Pokhri, is situated in a healthy part of 'the eastern Doon, but unculturable for want of water for drinking and domestic purposes. The Jakhun Rao at a spot a little 'above Bhogpoor and distant from it three miles, contains a supply 'of water during the whole year: it appears to me practicable 'that the water could be taken across at a spot marked on the 'map as Sureedhar and carried along the foot of the Hill to Ranee 'Pokhri Forest, and perhaps it could be thrown into a large tank 'now overgrown with jungle—or by proceeding higher up above 'this spot where water is turned off for the working of the mills 'now at Sureedhar, the water is already on this side of the Rao,

* There are lands on the right bank of the Tonse which might be irrigated from the Beejapoor water-course, especially those of Seedonwala and Jhujur. Captain Kirke having reported on the feasibility of carrying water over the bed of this river, and Mr. Vansittart having suggested that such should be done at the expense of a native gentleman who offered funds for the purpose, it is possible that this extension to the benefits derivable from the Beejapoor water-course may be hereafter carried into effect.

'and where the supply of it is much greater, could be carried 'along through rocks and under the village of Bumeyt and over a 'khud,* measuring 180 feet in breadth and 24 feet in depth, into 'the same spot as that to which it would arrive was it taken at 'Sureedhar." In requesting me to send an Officer to examine these lands, Mr. Vansittart remarks—"The same Officer might be di- 'rected to proceed to the hill village of Doomb, and to ascertain 'whether the water could be carried through the beautiful and 'naturally healthy valley that runs thence towards Rikekhes, I am 'convinced that large portions of this valley could be immediately 'brought under cultivation, and that I could persuade certain 'natives to provide the cost of the making of the pucka work and 'digging the trench, was the scheme reported practicable, and the 'cost not above 2,000 rupees. It appears to me that both these 'Canals have at one time been in existence. The valley above 'alluded to would be a splendid opening for European settlers, 'with a drawback only of its distance from a market." Had I had leisure either in the cold weather of 1843, or 1844, I should have visited the places above alluded to by Mr. Vansittart. I should suggest that an examination be made as early as can conveniently be managed, and at the same time the Jakhun river, and the country round about might be reported upon with reference to the establishment of lime manufactories† for the works on the Ganges Canal; this might lead to the necessity of connecting the manufactories with Hurdwar by good carriage roads, which would be another work of improvement.

61. The only Canal works that have as yet been completed in the Deyra Doon are the Rajpoor water-course with the mills

* Valley or Ravine.

† As the bed of the Song river contains a good deal of lime, it will in all probability be found more convenient to the Solani Aqueduct and to the larger works in that neighbourhood, to bring the material through the Kans Rao pass on Brinjarri bullocks, by which a considerable distance would be saved.

attached, and the Beejapoor water-course with its reservoirs and mills. The accounts and returns of these works are kept perfectly distinct and are under the executive charge of Captain Henry Kirke.

Expenditure and Returns—Rajpoor Water-course.

62. Appendix A. exhibits on the Dr's. side the total amount of sums already expended and for which bills have been submitted up to the 31st October 1844, on the Rajpoor water-course including every item of establishment, repairs, &c., the opposite side shews the receipts on the portion of the Khurreef or rain crop since the work was opened. At such an early stage it is impossible to draw any conclusions, or express any decided opinion as to what may ultimately be exhibited on the face of this return, although an idea may be formed by comparing it with that of the Beejapoor water-course: as the mills constructed on the Rajpoor line are numerous and as they are situated in more accessible situations than those of Beejapoor, the income from them will always give it advantages in the item of returns.

Expenditure and Returns—Beejapoor Water-course.

63. Appendix B. is a similar return of the Beejapoor water-course; viz. expenditure and receipts from its commencement up to the 31st October 1844, and Appendix C. is an abstract statement of the same. These papers will exhibit at a glance the difference between receipts and expenditure, and although a period of 4 years is not sufficient to raise the advantage of a work of this sort to maturity, it will shew very satisfactory results, and I hope act as an encouragement to further works of the sort being undertaken. In round numbers, one-third of the original outlay has been refunded—or nearly 30 per cent. has been recovered in a period of about 4 years.

Water-Rent for Lands irrigated, and Suggestions thereupon.

64. The cause of the high amount of income on land irrigated

on the Beejapoor water-course, during the three crops ending 31st October 1843, depended on contracts entered into with the grantees of the Hopeton Farm, which amounted to 1,500 rupees per annum or 750 rupees per crop—this contract was remitted at the period abovementioned in consequence of the embarrassment in which grantees were involved. The returns on this item have certainly not come up to the expectations held out, although they establish the fact that water is chiefly required during the Khurreef or rain crop for rice cultivation—during the Rubbee or cold weather crop, consisting of wheat, barley, &c. when rain falls in the early part of the season, and enables the Zumeendars to plough up their land, sufficient moisture appears to exist for the young plant to thrive, without any further aid from artificial irrigation, that is to say, *a crop is produced*, which is what the Zumeendars chiefly attend to; that actual produce however from a given surface would be greatly increased by irrigation is undoubted, and that the amount of water-rent levied is but a small payment for such excess of produce, are points which have been satisfactorily established by European farmers, and will, I have no doubt, be ultimately recognized by the native cultivators. At present one of the greatest improvements observable in the tracts which come under the influence of these water-courses is, the extent to which vegetable (especially onion) gardens, have been carried, all of which depend entirely upon irrigation. Fruit trees have also been planted in numerous places, and I have no doubt that backward as we may appear to be now, six years hence, (that is to say, when the Canal has flowed for a space of ten years,) the change for the better will be very perceptible. The water-rent on land irrigated is levied on crops as per Appendix D., it is one-half only of that taken on the Jumna Canals. I should however advocate a contract system, by which the interference of the Canal measuring establishment, and the vexatious disputes arising therefrom would be avoided. The levels being permanently fixed, and the water in the water-course being

free from silt, it would be by no means a difficult matter to give to each village a certain quantity of water, making it pay for the same by superficial measurement of opening, or so much per square inch, the only difficulty that occurs to me in this arrangement is, the allowance to be made for absorption, where lands lie at a considerable distance from the Canal. The contract given to the Hopeton Grant was never acted upon satisfactorily, and the value of the regulating head which was constructed, for securing to the grantees a certain quantity of water, was never sufficiently tested.

Rent on Water-Mills.

65. With exception to the saw-mill alluded to in para. 34, and a sugar-mill the property of the Hopeton Grantees, and established at the tail of their cut from the Beejapoor water-course, the only mills as yet in use are those in the native fashion for grinding corn. This species of corn-mill, which I have before described (as so simple in its parts, that the miller can himself keep it in repair,) can be established by the Government without the contingent expense of a large and expensive artificer's establishment—there can be no objection therefore to extending this sort of mill, as far as the demands of the country call for it. This, however, is not the case with mill work when the machinery is complicated, or liable to get out of order—here an expensive establishment of artificer's would be required, and even then the machinery would be liable to interruption from the breakage of parts only re-placeable by a reference to Calcutta or England, I have not therefore advocated any recommendation to Government, embracing the expenditure of public money on this point. I have limited this recommendation to the establishment of one of each sort of machine for either manufacturing or agricultural purposes, so as to shew the natives of this part of India the different ways that the water-power on these water-courses may be turned to account. I should go still further, and when a machine had been

approved of, and its uses fairly tested by the people of the district, I would take the first opportunity of disposing of it, and freeing both Government and the Canal Executive Officer from the trouble of keeping it in order and superintending its efficiency. On these grounds the Circular Saw-mill was proposed—and I would recommend that a set of vertical saws be also established. Sugar-mills are already understood from the one in use on the Hopeton Grant, it would therefore be unnecessary for Government to do anything further on that species of machinery: there are many varities however that may be set up with great advantage, for oil, cotton, &c., &c.

Sale of Wood and Grass.

66. The principles explained in para. 262 of my Notes on the Doab Canal, are rigidly enforced in the Doon, viz. that everything within the limits of the Canal boundary is property, and has its price returnable to the Canal Treasury—this item in the present case is of no great amount, but it will increase as cultivation increases, it consists of the sale of grass entirely.

Sundry Collections.

67. This item consists of filling tanks and watering cattle, and will be entirely abolished when the tank system is fairly established.

Fines for Breach of Canal Regulations.

68. An evil not to be dispensed with, but which ought to be limited as much as possible to cases where positive injury is done either to the works or to the arrangements for the regulation of the water. On the Rajpoor water-course where the channel passes through a city, these fines are particularly vexatious if awarded strictly agreeably to regulations. Previously to my departure, Mr. Vansittart had at my request made such arrangements with the Mohunt that any interference on the part of the Canal Establishment, with the channel in its progress through the

town would be prevented, a letter was also addressed by me to Captain Kirke to enter into correspondence on the subject with Mr. Vansittart and the Mohunt—it was however distinctly to be understood that the Mohunt was to have no sort of control over the water—but merely to protect, by his influence, the works.

Management of Works and Collections.

69. The executive duties of managing the works and collections are at the present time entrusted to Captain Kirke, under whom the whole of the works have been constructed. One Zillahdar, two Chuprassies and two Chokidars, whose duties are similar in every respect to those who hold the same situations on the Doab Canal, are attached to each of the water-courses, and the forms of paper, report, and correspondence between Captain Kirke and the Zillahdars, are also the same as on the Doab Canal. Bills for ordinary repairs and establishment are submitted on the 30th April and 31st October annually, at periods corresponding with the close of the Fusli accounts. The accounts of the two water-courses and their attendant works are kept *entirely separate*, and the members of the establishment of one water-course have nothing to say to the works or collections of the other. Captain Kirke receives a personal salary of 100 rupees a month, and is assisted in his office by one English and one native Writer, the first drawing a salary of 30 and the latter of 10 rupees per month. This total sum of 140 Rupees is chargeable in the proportion of two-thirds to the Rajpoor and one-third to the Beejapoor water-course.

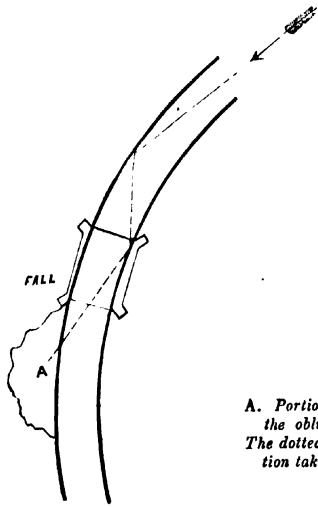
Hydraulic and Meteorological Observations recommended.

70. Daily registers of the barometer, thermometer, and wet bulb thermometer, ought to be kept by the officer in charge of these water-courses, and I cannot too strongly impress on his attention, the value that might be derived from careful observations on the discharge, as well as upon all points regarding the flow of

water and position of deposits of silt in his water-courses—the extent of masonry channel with a well-defined section, continued on lines both straight and on a variety of curves, offers a fine field for investigations on these interesting subjects.

71. There are many points which, by being brought to notice from observations on these small streams, might be the means of aiding the Engineer who is engaged on larger works connected either with canals or rivers: on the Beejapoor water-course for instance, by way of example, and to shew that falls ought to be built at points where the alignment is straight, a masonry descent or fall has been constructed on a curve: it is observed that the rush of water in passing over the tail sets upon one side only, cutting the embankments away to an extent that is exhibited at no other fall, thus :—.

DIAGRAM. I.

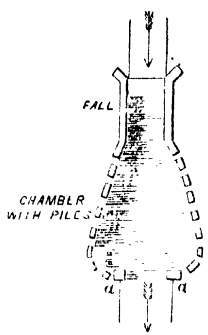


A. *Portion of Bank removed by the obliquity of the Current. The dotted line shews the direction taken by the Current.*

72. The reason of this cutting away is very obvious, but it was overlooked at the time, and in all probability had the observation not been made, the error would have been persevered in.

The stream is so small in the Beejapoor water-course, that there s no great difficulty in remedying the evil, but had it occurred in lealing with a large body of water, the consequences might have been serious. Observations on the action of water at the tails of falls, or at that point where the current leaves a masonry bed to act upon the natural soil, are very desirable. Captain Kirke has, n using a modification of the form adopted in the chambers of some of the regulating heads in the water-courses in Italy, succeeded in some measure in obtaining a satisfactory result, the shape of the reservoir into which the water falls, and in which it expends a portion of its agitation, is in the form of a pear, in other words the piling which is usually carried in a direct line on each flank, so as to protect the sides from injury, is under this arrangement, curved inwards at the point where the water leaves the work, thus:—

DIAGRAM. II.



73. In some cases this plan has materially put a stop to the wear on the banks at the points *a a* between which the stream passes off in a fair direction down the channel.

P. T. CAUTLEY, *Capt.*,
Supdt. Canals, Doab, &c.

February 12th, 1845.

APPENDIX.

APPEN.

Dr. RAJPOOR

Bill No. 7, passed by Military Board, 23rd January, 1844, Establishment to 31st October, 1843,	906	10	8
Bill No. 9, passed by Military Board, 9th August, 1844, Establishment to 30th April, 1844,	624	0	0
Bill No. 12, (not passed), constructing Rajpoor Water-course.	42984	11	9
Bill, (not passed), Plantations, up to 30th April, 1844,	179	9	6
Bill, (not passed), Compensation to Millers,	2743	12	0
Bill, Office Contingencies to 30th April, 1844, passed 11th Oct., 1844, two-thirds,	72	13	4
Bill No. 1, passed by Military Board, 23rd October, 1844, for keeping open old Line Rajpoor Water-course,	552	12	10
Bill No. 2, passed by Military Board, 12th November, 1844, for keeping open old Line Rajpoor Water-course,	413	11	0
Bill No. 13, (not passed), for Establishment to 31st October, 1844,	787	0	0
Bill No. 15, (not passed), for Ordinary Repairs, to 31st October, 1844,	777	7	0
Total Rupees,	50042	8	1

P. T. CAUTLEY, *Capt.*,
Sup. Canals, Doab, &c.

DIX A.

WATER-COURSE. *Cr.*

To 31st May, 1844.	SUMS RECEIVED FROM OLD WATER-COURSE, *vide* OUTLAY PER CONTRA.			
	Water-Rent for 1842-43, and up to 31st May, 1844, .	386 7 9		
	Water-Mill Rent do., do., .	1144 0 0		
	Fines, &c., do., do., . .	44 4 9		
		1574	12	6
From 1st of June, 1844, to 31st Oct., 1844,	SUMS RECEIVED FROM NEW WATER-COURSE SINCE WATER WAS ADMITTED.			
	By Water-Rent, . . .	136 0 8		
	,, Mill-Rent . . .	851 5 10		
	,, Fines, ...	16 14 0		
		1004	4	3
	Total Rupees, . . .	2579	1	0

HENRY KIRKE, *Capt.*,
Ex. Officer, Doon Water-courses.

APPEN-

Dr. BEEJAPOOR

Bill No. 59, passed by Government, 13th Nov. 1840, constructing Water-course, . .	15926	14	7
Bill No. 66, passed by Government, 30th July, 1841, constructing Bridges, . . .	744	0	0
Bill No. 67, passed by Government, 8th Sept. 1841, constructing Falls, ...	6364	2	4
Bill No. 74, passed by Government, 8th March 1842, constructing Mills, ...	3109	14	10
Contingent Bill No. 27, passed by Government, 27th July, 1838, Survey Expenses, .	62	12	3
Ditto, ditto, No. 50, ditto by ditto, 6th August, 1841, Remuneration to Captain Kirke,.	697	12	3
Ditto, ditto, No. 55, ditto by ditto, March, 1842, ditto, ditto, ...	653	7	9
Bill No. 1, passed by Military Board, 30th July, 1843, Ordinary Repairs to 1st May, 1840, ...	2996	2	8
Ditto, No. 2, ditto by ditto, 18th March, 1842, ditto, ditto, 31st October, 1841, . .	780	7	1
Ditto, No. 3, ditto by ditto, 23rd March, 1843, ditto, ditto, 30th April, 1842, . .	1053	7	10
Ditto, No. 4, ditto by ditto, 10th March, 1843, ditto, ditto, 31st October, 1842, . .	1131	11	4
Ditto, No. 5, ditto by ditto, 28th July, 1843, ditto, ditto, 30th April, 1843, . .	1202	12	4
Ditto, No. 6, ditto by ditto, 23rd January, 1844, Establishment, 31st October, 1843, .	421	5	4
Ditto, No. 6, ditto by ditto, 23rd January, 1844, Ordinary Repair, 32st Oct. 1843, .	767	8	0
Ditto, No. 8, ditto by ditto, 12th November, 1844, ditto, ditto, 30th April 1844, .	640	12	9
Ditto, No. 10, ditto by ditto, 9th August, 1844, Establishment, 30th April, 1844, .	448	0	0
Ditto, Office Contingencies, passed by Military Board, 11th October, 1844, one-third,.	36	6	8
Ditto, (not passed), for Plantations to 30th April, 1844, ...	179	13	6
Ditto, No. 14, (not passed), for Establishment to 31st October 1844, ...	465	8	0
Ditto, No. 16, (not passed) for Ordinary Repairs to 31st October, 1844, . .	539	1	8
Total Rupees, . .	38222	1	2

P. T. CAUTLEY, *Capt.*,
Supdt. Canals, Doab, &c.

DIX B.

WATER-COURSES. *Cr.*

From 1st May '40, to 30th April '41	Water-Rent,	315 1 8			
	Fines,	28 7 3	343	8	11
1st May '41 to 30th April '42	Water-Rent,	371 2 2			
	Mill-Rent,	1132 11 2			
	Sale of Wood and Grass,	3 8 0			
	Sundries,	190 13 0			
	Fines,	185 5 6	1883	7	10
1st May '42 to 30th April '43	Water-Rent,	1924 6 8			
	Mill-Rent,	1972 13 2			
	Sale of Wood and Grass,	3 8 0			
	Fines,	243 9 0	4144	4	10
1st May '43 to 30th April '44	Water-Rent,	1149 0 2			
	Mill-Rent,	2189 8 4			
	Sale of Wood, &c.,	8 0 0			
	Fines,	244 12 6	3591	5	0
1st May '43 to 31st Oct. '43	Water-Rent,	418 6 4			
	Mill-Rent,	1020 3 11			
	Fines,	43 6 0	1482	0	3
	Total Rupees,		11444	10	10

HENRY KIRKE, *Capt.*,
Ex. Officer, Doon Water-Courses.

APPENDIX C.

Abstract Statement of the Direct Canal Revenue, with Ordinary Repairs and Establishment, Beejapoor Water-course.

		Rent on Land Irrigated.			Rent on Water Mills.			Sale of Wood and Grass.			Sundry Collections, filling Tanks, &c.			Fines for Breach of Regulations.			Total Half-yearly Income.			Cost of Establishment.			Cost of Ordinary Repairs.			Total Half-yearly Expenditure.			Annual. Income.			Annual. Expenditure.		
1840-41,	1st May 1840 to 30th April 1841,	315	1	8	...	...	...	...	...	...	0	3	0	28	7	3	343	8	11	336	0	0	2660	2	8	2996	2	8	343	8	11	2996	2	8
1841-42,	1st May 1841 to 31st October 1841,	277	15	2	...	...	...	...	...	...	3	0	0	119	8	6	400	7	8	168	0	0	612	7	1	780	7	1	1883	7	10	1883	14	11
	1st November 1841 to 30th April '42,	93	3	0	1132	11	2	3	8	0	187	13	0	65	13	0	1483	0	2	645	1	2	408	6	8	1053	7	10						
1842-43,	1st May 1842 to 31st October 1842,	1139	4	9	920	5	3	2	0	0	...	...	...	201	5	0	2262	15	0	768	0	0	363	11	4	1131	11	4	4144	4	10	2334	7	8
	1st November 1842 to 30th April '43,	785	1	11	1052	7	11	1	8	0	...	...	...	42	4	0	1881	5	10	368	0	0	834	12	4	1202	12	4						
1843-44,	1st May 1843 to 31st October 1843,	1080	3	6	999	14	10	1	0	0	...	...	...	95	0	6	2176	2	10	421	5	4	767	8	0	1188	13	4	3591	5	0	2277	10	1
	1st November 1843 to 30th April '44,	68	12	8	1189	9	6	7	0	0	...	...	...	149	12	0	1415	2	2	448	0	0	640	12	2	1088	12	9						
1844-45,	1st May 1844 to 31st October 1844,	184	6	4	1020	3	11	...	...	...	...	...	...	43	6	0	1482	0	8	448	0	0	539	7	8	987	1	8						

P. T. CAUTLEY, *Capt.*,
Supdt. Canals, Doab, &c.

HENRY KIRKE *Capt.*,
Ex. Officer, Doon Water-courses.

APPENDIX D.

RATES of Water-rent levied on Lands Irrigated from the Canals in the Deyra Doon, according to the value of the Crops grown, and relative facilities for using the Water.

		On Lands Irrigated naturally.						On Lands Irrigated artificially.						
		Per Beegah.			Per Biswa.			Per Beegah.			Per Biswa.			
1st Class,	Fruit, Gardens or Orchards, ...	1	9	0	0	1	3	1	4	0	0	1	0	Per annum.
	Ditto, ditto, with Vegetables underneath,													
	Nursery Gardens, ...													
2nd Class,	Vegetable Gardens, ...	0	10	0	0	0	6	0	7	6	0	0	4½	Per annum or Crops.
	Fruit Trees with Grain underneath, ...													
	Indigo, Sugar Cane, Tobacco, Singharas,													
	Cultivated Grasses, Ujwain, Mussallas, ..													
3rd Class,	Rice, Cotton, Wheat, Oats, Indian Corn,	0	5	0	0	0	3	0	3	4	0	0	2	Per Crop.
	Gochni, ...													
	Vegetables, single crops, Safflower, Urruhr,													
4th Class,	Gram, Barley, Oil Seeds of varieties, Cheena,	0	3	4	0	0	2	0	2	6	0	0	1½	Per Crop.
	Mundowa, Jowar, ...													
	Dals of varieties, Bajra, Mote, ...													

The Beegah is considered as that of 55 yards square.

P. T. CAUTLEY, *Capt.*
Supdt. Canals, Doab, &c.