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Sir ALEXANDER B. W. KENNEDY, LL.D., F.R.S, President, in the Chair.

(*Paper No. 3611.*)

"The Talla Water-Supply of the Edinburgh and District Waterworks."

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SINCE the date of the Paper[1] by the late Mr. Alexander Leslie, M. Inst. C.E., additions involving an expenditure of about £1,500,000 have been made by the Edinburgh and District Water Trustees to their works. By far the greater part of this expenditure has been in connection with the introduction of a supply from the Talla Water, one of the tributaries of the River Tweed near its source in Peeblesshire.

INCEPTION OF THE TALLA SCHEME.

So long ago as September, 1888, the Trustees considered a memorandum by their engineers as to a proposed additional supply of water from the Manor Valley, when they called for a report on the various available sources of water-supply, including the Manor, St. Mary's Loch, the Talla, and the Tweed. The engineers were instructed at the same time to continue to prosecute their investigations for the detection and checking of waste, a matter which still continues to occupy the attention of a special staff of men day and night.

The Trustees agreed with the opinion of the engineers that, as a considerable time—probably 7 or 8 years—might elapse before any new supply could be made available, it would not be prudent to delay much longer the making of suitable arrangements for obtaining

[1] "The Edinburgh Waterworks," Minutes of Proceedings Inst. C.E., vol. lxxiv, p. 91.

an additional supply. As events turned out, twice the time named actually elapsed before the introduction of the new supply from Talla in 1905.

The Manor scheme was recommended for several reasons, among which were the excellent quality of the water, the proximity of the source to Edinburgh, and the fact that the cost of the first instalment was estimated to be less than for the other schemes under consideration.

For several years, while various reports were under discussion, matters moved somewhat slowly, and considerable difficulty was experienced by the Trustees in persuading the public generally how little margin there was between the daily quantity of water then required for a full supply to the district (about 15 million gallons) and the daily supply of water available from the Trustees' existing works, which was estimated as follows:—

(*a*) In average years about 15 million gallons.

(*b*) In a dry period about 13¾ million gallons.

(*c*) In an excessively dry year like 1870, about 12½ million gallons.

With regard to the consumption, it must be recognized that Scottish towns consume more water per head of population than the large manufacturing towns of England, the houses in which, being of an essentially different character, are not provided to the same extent as Edinburgh with baths, water-closets, hot water and sanitary appliances. The total consumption in Edinburgh occasionally exceeds 40 gallons per head of population per day.

The following Table shows the population and the quantity of water supplied for domestic purposes and for trade and sanitary purposes, both when the Trust was constituted and in 1905:—

	1870–71	1904–05	Increase.
Population supplied .	254,000	448,500	194,500
Water supplied for domestic purposes, shops, &c. . . .	20·4 gallons per head per day	26·5 gallons per head per day [1]	6·1 gallons per head per day
Water supplied for trade and sanitary purposes . . .	882,000 gallons per day	5,382,000 gallons per day	4,500,000 gallons per day

[1] Including Musselburgh, Dalkeith, etc.

It was decided in 1892 not to increase the storage of the existing reservoirs, because it was felt that, even though additional storage might to some extent augment the supply then available, it could only stave off for a time the introduction of water from an entirely fresh source, when the money spent on additional storage on the present watersheds would not be properly utilized.

Having definitely settled that a new supply was required from a fresh source, it became necessary to decide upon the scheme to be adopted from among the three under consideration, namely, Manor, St. Mary's Loch, and Talla. The relative positions of the three watersheds are shown in Fig. 1, Plate 3, and the proposed lines of aqueducts into Alnwickhill have also been indicated.

Borings and trial-pits were sunk with a view to estimate the depth to which the puddle trenches would require to be carried at the several proposed sites of embankments. The results of these borings showed that in the case of the Manor scheme the depth from the surface of the ground to the top of the rock was 149 feet at one point, while at another point a bore-hole was sunk 70 feet without reaching rock. The configuration of the surrounding country might have made it expensive to extend the Manor watershed at a later date.

In the case of St. Mary's Loch, no rock having being found at a depth of over 100 feet, it was not considered advisable to attempt to raise the surface of the water to any large extent: instead of doing so it was proposed to lower the water-level of the Loch by constructing a tunnel whose sill would be situated about 37 feet below the ordinary summer level of the loch. This proposal involved the drying-up of the bed of the Yarrow for about 2 miles below its outlet from the loch, except when the loch was overflowing.

In the case of the Talla reservoir (Fig. 2, Plate 3), the trial-pits and borings indicated that a satisfactory bottom for the puddle trench might be obtained at a moderate depth. The Talla scheme, although involving a longer aqueduct than the Manor scheme, had the great advantage over the latter that the drainage-area is capable of very considerable extension at moderate cost, by taking in other tributaries of the Tweed near its source. The nearest place where a sufficient quantity of clay suitable for puddle was found was close to Broughton railway-station, about 9 miles from the embankment. As it was evident at the outset that both the surface and gradients of the public road were unsuited for carting quantities of material to the reservoir, including about 100,000 tons of clay, a tramway along the public road from Broughton to Talla formed a part of the scheme.

After carefully considering all the circumstances, the Trustees decided in the middle of October, 1894, to proceed with an application to Parliament for power to construct the Talla works. It was at that time expected that the yield of the drainage-area would provide about 8 million gallons per day for supply purposes and 4 million gallons per day for compensation to the Talla and the Tweed. In the short time available before the 30th November, the necessary parliamentary plans were prepared and lodged for the Talla reservoir and aqueduct and a proposed service-reservoir at Fairmilehead near Edinburgh; also for a railway 9½ miles in length, in place of the tramway above referred to, which the Peebles County Council had threatened to oppose. The railway, which is of normal gauge, was laid out on the same bank of the River Tweed as the aqueduct, in order that it might be of service in getting forward the necessary materials for that portion of the aqueduct which lies in the valley of the Tweed, though its principal object was to bring up clay, etc., to the reservoir. After the railway was in operation, it was decided to bring the clay from near Carluke, instead of from Broughton, partly because clay of an excellent quality was to be found at Carluke and had by that time been successfully used in a reservoir in a neighbouring valley to Talla, and partly because the land at Broughton might be subject to flooding when the Biggar Water was in spate. Nine separate petitions were lodged against the Bill in the House of Lords and two in the House of Commons; but agreements having been arrived at with all the petitioners, the Bill, after the insertion of protective clauses as to compensation-water and the fisheries, passed unopposed through both Houses and received the Royal Assent on the 30th May, 1895.

Rainfall and Discharge of the Talla Drainage-Area.

One of the protective clauses referred to provided that the compensation-water should be one-third of the available rainfall as determined by two arbitrators ("arbiters" in Scots law), who were to settle the amount after placing rain-gauges upon the drainage-area and taking regular readings over a period of 7 years. Mr. B. Hall Blyth, M. Inst. C.E., was nominated by the persons interested in the waters of Talla and Tweed, while the Trustees nominated their Engineer, the late Mr. James Wilson, M. Inst. C.E., and afterwards the Author. Fig. 1, Plate 3, shows the outline of the drainage-area; the sites of the rain-gauges were fixed by the arbitrators so as to afford a proper representation of the rain falling upon the drainage-area. The following Table shows the comparative elevation above sea-level.

After collecting all the available data, and before proceeding to consider their award, Mr. Blyth and the Author arranged that the late Mr. James Mansergh, Past-President Inst. C.E., should act as

Height above Ordnance Datum.	Area in Acres.
Below 950 feet	290
950 to 1,000 feet	140
1,000 „ 1,250 „	510
1,250 „ 1,500 „	720
1,500 „ 1,750 „	790
1,750 „ 2,000 „	1,290
2,000 „ 2,500 „	2,250
Above 2,500 feet	190
Total	6,180

umpire ("oversman" in Scots law) in the event of any difference arising between them. Having regard to the fact that monthly readings of the gauges had been taken by their representatives throughout the 7 years, and that daily readings had been taken of several check-gauges by shepherds and by a schoolmaster resident in the neighbourhood, no question arose as to the data on which to proceed. The net result of the gaugings showed that the average annual rainfall on the drainage-area during the period of 7 years was 62·51 inches. In comparing the rainfall recorded over a long series of years at other gauges, dispersed over a very wide extent of country, with that for the particular years during which observations had been made on the Talla drainage-area, the arbitrators agreed that a correction of 4 per cent., to be added to the recorded rainfall, was required in order that the true average rainfall over a long period might be obtained. This made the average annual rainfall, taken over a long period, 65 inches. The deduction for evaporation, absorption, etc., had been settled at 15 inches at an early stage in the reference. The only point the umpire was called upon to deal with was, to what extent a deduction should be made in order to arrive at the available rainfall in the driest three consecutive years. The compensation-clause in the Act did not expressly provide for this, but the umpire, after hearing the opinions of the arbitrators, decided in favour of a deduction of 12 inches.

The available rainfall in ordinary dry years has thus been determined by the arbitrators to be 38 inches per annum. Upon this basis the yield of the drainage-areas in dry years will be 14,598,000 gallons per day, of which one-third is being given as compensation to the Talla and the Tweed. The highest rainfall recorded at Talla in any one of the 7 years dealt with by the arbitrators at any gauge was 89·88 inches, and the lowest in any one year was 36·37 inches at another gauge.

The 7 years dealt with by the arbitrators were 1896–1902 inclusive. The rainfall during these 7 years, and subsequently, is recorded in the Tables of Appendix I to this Paper (pp. 134–143).

At the three stations, 5*a*, 6*a*, and 7*a*, where both daily and monthly readings were kept, the two sets of readings agree very closely indeed for this 7-year period. The average annual rainfall at these stations, calculated from the daily readings, was 61·00 inches, while the corresponding amount from the monthly readings was 61·01 inches. The number of days on which no rain fell during the 7 years under consideration was 1,036 days at gauge 5*a*, 1,095 days at gauge 6*a*, and 1,118 days at gauge 7*a*. The days on which less than 0·1 inch fell were respectively, 1,508, 1,582 and 1,718; while the days on which more than 1 inch fell were 118, 70, and 34. There were thirty-six records of more than 2 inches on one day, and of these twenty-five were at 5*a*, eight at 6*a*, and three at 7*a*. There were three readings of over 3 inches, all at gauge 5*a*; and the highest recorded reading on any one day was on the 1st November, 1898, when 3·57 inches of rain fell at that point. The heaviest continuous rainfall occurred on the 26th–30th December, 1897, inclusive, five days in all, when 9·99 inches were recorded at gauge 5*a*, 8·23 inches at gauge 6*a*, and 5·02 inches at gauge 7*a*.

The continuation of the observations in recent years has added sixteen daily records of more than 2 inches, and two records of more than 3 inches. The longest period of practically continuous rainfall seems to have been from the 20th January to the 6th March, 1903, when, notwithstanding one period of 2 days and another period of 8 days when no rain was recorded, there was a total fall of 22·61 inches distributed over the whole period of 46 days. The greatest rainfall in any one month was in March, 1903, when it ranged from 12·18 inches at gauge No. 2 to 25·18 inches at gauge No. 5*a*. This last is the heaviest monthly fall recorded during the whole period since the gauges were placed in position. The total rainfall recorded at gauge 5*a* in the year 1903 was 115·92 inches, which is the highest reading at any gauge during a complete year.

Having regard to the very varying altitude of the drainage-area, the arbitrators considered whether or not a percentage correction should be made on this account, but they satisfied themselves that the rule as to correction which sometimes obtains could not be accepted for this drainage-area. The following Table shows the average rainfall at the different gauges, with their Ordnance levels, from which it appears that the greatest rainfall took place at gauge No. 5*a*, 1,090 feet lower than the gauge situated at the highest elevation.

One inch of available rainfall over the Talla drainage-area represents about 140 million gallons.

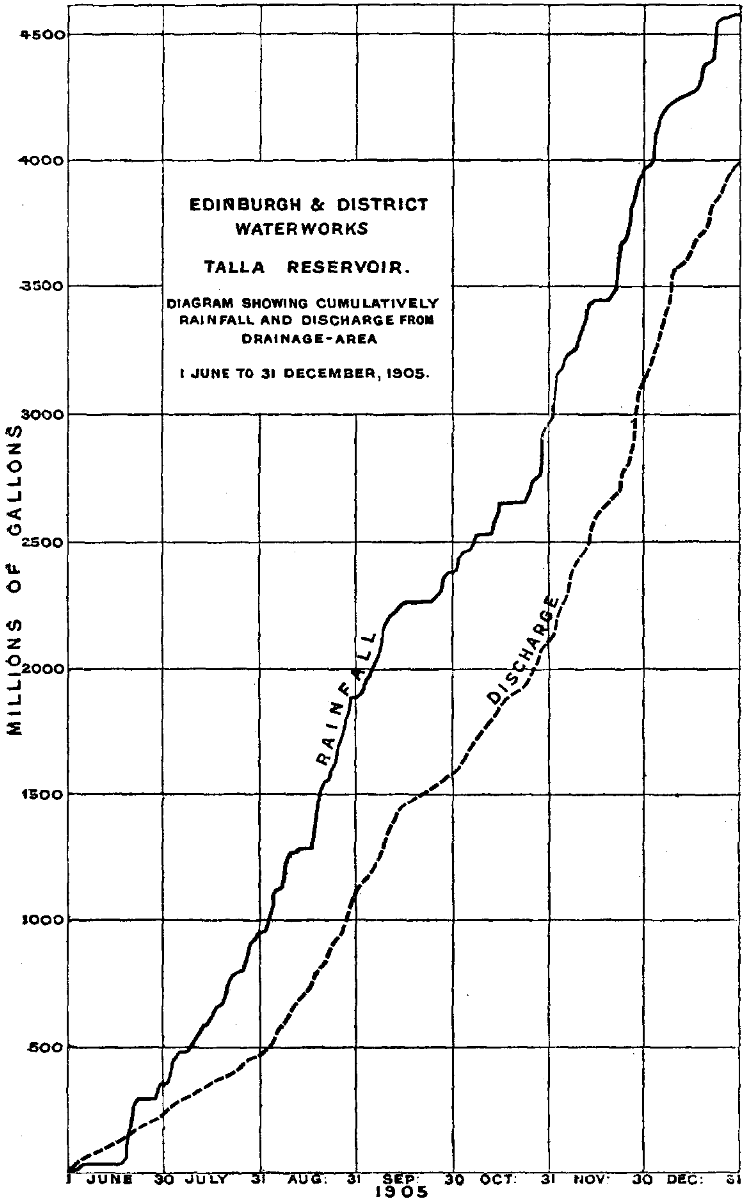
Gauge.	Elevation.	Average Annual Rainfall.	Gauge.	Elevation.	Average Annual Rainfall.
	Feet above Ordnance Datum.	Inches.		Feet above Ordnance Datum	Inches.
No. 1 .	1,496	56·23	No. 5*a*	1,537	73·92
„ 2 .	2,627	65·53	„ 6*a*	966	61·43
„ 3 .	2,258	66·02	„ 7*a*	1,196	47·66
„ 4 .	1,860	66·81			

The opportunity has been taken to carry on a series of careful records, not only of the water falling upon the drainage-area but also of the water actually running off that area (*Fig. 3* [1]). This information was obtained for the period of filling, the table of contents of the reservoir having been prepared from a number of cross sections, and the water-levels having been carefully noted in a sheltered spot. Besides this, an evaporation-gauge has lately been erected close to the measuring-house, and observations are being taken regularly. This gauge, which was made by Messrs. Negretti and Zambra, consists of a galvanized-iron tank 6 feet square and 2 feet deep, sunk in the ground to within 3 inches of the rim. The level of the water in the tank is read daily at noon by means of a hook-gauge and compared in the usual way with the rainfall-readings. A similar gauge has recently been erected at Glencorse filters, with a view to continuing the long series of observations of evaporation commenced by the late Mr. James Leslie in 1853, which are recorded in Mr. Alexander Leslie's Paper already referred to, and which are continued to date in Appendix II to the present Paper (pp. 144–151).

For some time after the impounding of water began, the only water discharged through the sluices was the compensation-water to the stream. Since September, 1905, water has been taken through the aqueduct for town consumption, but for ease of reference no distinction has been made between the water discharged through the aqueduct and the water sent down the stream as compensation. The average of the recorded rainfall has been taken, converted into the quantity falling on the drainage-area of 6,180 acres, and compared with the quantity of water resulting therefrom.

[1] The filling of the reservoir and regular discharge of compensation-water began on the 20th May, 1905. Water was first sent into Edinburgh in September, 1905; and the reservoir first overflowed 14th January, 1906.

Fig. 3.


EDINBURGH & DISTRICT
WATERWORKS
TALLA RESERVOIR.
DIAGRAM SHOWING CUMULATIVELY
RAINFALL AND DISCHARGE FROM
DRAINAGE-AREA
1 JUNE TO 31 DECEMBER, 1905.
MILLIONS OF GALLONS
4500
4000
3500
3000
2500
2000
1500
1000
500
RAINFALL
DISCHARGE
1 JUNE 30 JULY 31 AUG: 31 SEP: 30 OCT: 31 NOV: 30 DEC: 31
1905

It is obvious from *Fig. 3* that a comparison should not be made of the rainfall in a given month with the water yielded in that month, without taking account of the actual flow in the river at the moment when the observations began. Having regard, however, to the observations which have been made, it would appear that, during the 5 months following the 20th May, 1905, when the sluices were shut down, the ratio of the available water to the actual rainfall was somewhat higher than the figures brought out by the rain-gauge arbitrators. One point of some little importance should be mentioned at this stage, namely, that the actual area of water in the reservoir during May and June, 1905, was less than 140 acres; hence the total quantity lost in those months by evaporation from the reservoir itself was probably considerably less than it is likely to be at similar seasons in future. When the reservoir is half full the surface area of water is about 230 acres.

A further protective clause in the Act which was referred to arbitrators (under the provisions of the Lands Clauses Act) involved the question whether the salmon-fisheries in the River Tweed would be affected injuriously by the construction of the Talla reservoir and the consequent abstraction of water from the river. At the request of the Tweed Commissioners a clause was inserted in the Act providing that no fish-ladder or fish-pass should be constructed into the Talla reservoir.

In due course the Commissioners made a claim of £8,000 sterling for injury to the fisheries of the Tweed, basing the claim on the abstraction from the River Tweed of a large and valuable amount of pure water which they considered material for the purpose of attracting the fish up the river, particularly as it was alleged that for a length of about 16 miles in the neighbourhood of Galashiels (40 miles below the reservoir-embankment) the Tweed was much polluted. The Commissioners further laid great stress on the loss of spawning-ground within the area of the proposed reservoir and upon the injury that would be caused by the loss of freshets and floods. The total drainage-area over which the Trustees obtained control was, as already stated, 6,180 acres, and as the water from one-third of this area was reserved to the River Tweed in terms of the compensation-clause the total area to be diverted might be stated at 4,128 acres. This is nearly one-three-hundredth part of the total drainage-area of the River Tweed above the point where it becomes tidal—a distance of 80 miles. The area to be diverted is also about one-fortieth part of the drainage-area at Peebles, 19 miles below the reservoir.

The arbitrators having differed, the umpire awarded the Tweed

Commissioners the sum of £2,250 for injury to the salmon-fisheries by destruction of spawning-beds above the embankment resulting from the construction of the Talla reservoir, for injury to the said fisheries by abstraction of pure water from the river, and for all other injuries caused by the construction of the reservoir.

The Reservoir.

Site.—Practically the whole gathering-ground, which is mainly hill pasture (with about 440 acres of peat) has been acquired, at a cost of about £36,000, by the Trustees, who are thus enabled to preserve the purity of the water draining into the reservoir. If the Trustees had not purchased the drainage-area, they would still have had to acquire more than 400 acres for the reservoir-site, embankment, etc. Moreover, they derive a rent of a little more than £300 per annum for the hill pasture above the water-level of the reservoir. The reservoir-site has a great deal to recommend it. The bed is very flat, as may be seen from the following data:—The surface area is 300 acres, its length is 2½ miles, the depth at the embankment is 80 feet, and the length of the embankment measured along the top water-line is 350 yards. A bend in the glen about 1,200 yards above the embankment shelters the greater portion of its length from the full fetch of the waves. The elevation of the site is also favourable for a supply by gravitation to a large area varying between sea-level and nearly 600 feet above Ordnance datum, and the available rainfall is comparatively high. One drawback to the site was the total absence of reliable clay, already referred to: also, the friable nature of the local rock made it quite unsuitable for most purposes. The contractor consequently found it cheaper to procure all the squared pitching from quarries at North Queensferry and Craigleith. All the masonry was built of red Dumfriesshire sandstone with the exception of the inner tower, which was built of parpend whinstone, while the house over this tower was built of granite.

Construction.—The railway contract was the first to be let, as the line was required for the construction of the reservoir. The railway crosses the River Tweed and the Biggar Water with bridges of 100 feet and 60 feet span respectively, and there are four other bridges at crossings of public roads in addition to a number of accommodation-bridges. The steepness and sidelong nature of the ground at several places in the Tweed Valley, and the proximity of the public road to the river at various points, necessitated the construction of considerable lengths of concrete retainingwall. The total cost of the railway (exclusive of land) was about £60,000, or £6,300 per mile. Steel rails weighing 75 lbs. per yard were used, with 35-lb. chairs.

The railway has been of the greatest use in getting all sorts of material and apparatus both to the reservoir and to the access-roads leading to various points along the line of the aqueduct. The Trustees are forbidden to charge tolls on the railway, and can only use it for their own purposes and the construction of the works. The ruling gradient is 1 in 50.

The opportunity was taken while the railway work was in progress to have a portion of the puddle-trench for the reservoir opened up, so that intending tenderers might have the best opportunities for considering the nature of the material which would be met with in sinking the trench. This undoubtedly was a convenience, but the extent to which the trench was opened up did not suffice to give warning as to the existence of various fissures which were afterwards disclosed.

The construction of the railway occupied about 2½ years, and when it was approaching completion the reservoir contract was let.

The sill of the waste weir is 950 feet above Ordnance datum, and when filled the reservoir has a surface area of 300 acres and a total capacity of about 2,800 million gallons, including about 160 million gallons below the level at which water can be drawn off by gravitation to the aqueduct. The reservoir-works have cost altogether about £251,000, or £560 per million cubic feet of storage. The top of the embankment (Fig. 4, Plate 3) is 7 feet above top water-level and is 20 feet broad. The greatest depth of trench below the surface of the ground is 82 feet. The puddle-wall is 10 feet wide at the top of the embankment, and its maximum width at ground-level is 32 feet. The contents of the embankment, including puddle, pitching, soiling, etc., are about 500,000 cubic yards. From the top of the embankment to 10 feet below top water-level the face of the embankment is protected with 12-inch squared pitching set on 12 inches of broken stone. This squared whinstone pitching cost, when set in place, 16*s*. per square yard. Below the squared pitching there is 12-inch rubble pitching to a level of 30 feet below top water, and the remainder of the slope is covered with beaching 18 inches deep.

The reservoir contract was let to Messrs. James Young and Son, of Edinburgh, and at the end of April, 1897, they began to strip the site of the embankment and to excavate the puddle-trench, etc. It was originally intended to dispose of the flood-waters by means of a culvert to be constructed across the line of the embankment near to the course of the Talla Water, but it was decided, before the letting of the contract, to drive a tunnel instead through the solid ground on the east side of the valley, and quite clear of the main embankment. This alteration of the arrangement of the outlet-works increased the cost beyond the parliamentary estimate, partly on account of the additional work involved in the first instance, partly also on account of a greater length of puddle-trench than was originally contemplated being necessary to ensure water-tightness, and partly for another reason which is referred to later. The tunnel, which is about 400 yards in length, is roughly V-shaped in plan, and was driven almost entirely through greywacke. The work of driving was carried on chiefly from the two shafts nearest the inlet and outlet ends of the tunnel towards the apex of the V, which was a little way eastward of the intended east end of the puddle trench. Comparatively little water was encountered and the driving occupied about 9 months, the greatest progress at either face being about 22 lineal yards in 1 month. No machine-drills were used. There are three shafts on the line of the tunnel, but, partly owing to the time taken in sinking the deepest shaft at the apex of the V, little use was made of it in driving the tunnel. On the completion of the driving a beginning was made with the lining. Fig. 5, Plate 3, is a typical cross section of the tunnel, which measures 15 feet by 13 feet 6 inches inside the brickwork. The invert is of concrete faced with one ring of blue brick, and it was put in at an early stage. Four rings of brick-work were usually adopted in the side walls and arch, the space between the back of the brickwork and the rock being tightly packed by hand with concrete. At the same time the masonry of the bottom of the shafts and at the two mouths of the tunnel was proceeded with. The total cost of the tunnel, including the inlet and outlet and all the lining, as well as the excavation of the shafts and the masonry up to the level of the soffit of the tunnel, was £20,000. Some progress was made with the excavation of the puddle-trench and the stripping of the site of the embankment during the driving of the tunnel. To allow the excavation of the trench at the lowest part of the valley to be proceeded with, a timber trough was erected across the trench in July, 1898, to carry the Talla Water until the tunnel was available. The trough was about 15 feet wide and its sides were about 3 feet high. It was built of 9-inch by 3-inch battens and caulked with oakum, and it was supported across the trench by 12-inch by 12-inch beams. A fall of 9 inches in the length was given to the trough, and it proved capable of dealing with the flood-water until about the middle of

October, when the trench was flooded during a period of heavy rains. The flooding of the trench was attributed to the water passing through the gravelly ground at one side of the trough where a diversion had been cut while the trough was being put in position. Further sinking-operations were accordingly delayed for about 8 months until the tunnel was sufficiently completed to allow the Talla Water to be diverted through it. This was done at the end of May, 1899. The trench was then pumped dry, and after some further excavation had been taken out, a start was made with the putting in of puddle, in July, 1899.

The death of the principal partner of the contractors was followed shortly by the failure of the firm, which in the interval had been converted into a limited-liability company. Work to the extent of about £55,000 had then been performed, out of a contract-sum of £160,000. The Trustees took the work out of the contractors' hands and arranged immediately for reletting it; but they carried on the work of putting in puddle in the trench for a time by administration while various legal formalities were being complied with and new schedules were being prepared.

The reservoir contract was relet in December, 1899, to Mr. Best, of Edinburgh, at a contract price of £150,000. During the winter of 1899–1900 work at the reservoir was practically at a standstill, as all the workmen, with the exception of those looking after the pumps, had been paid off. When the new contractor started work in the spring of 1900 it was found that in some places the timbering of the puddle-trench had slackened very considerably, and that several slips had occurred in the rock, which lay at a fairly steep angle, on the sides of the trench: so much so as to make it unsafe for men to work at various places in the bottom. It was then arranged that the timber should be removed and that the sides of the trench should be sloped off above the level of the rock after leaving a sufficient bench. This work was put in hand forthwith, and the puddle which had already been put in the trench was covered with timber sheeting in order to prevent the stones and earth, falling down during the dressing-off of the sides, from mixing with the puddle. The alteration unfortunately involved some loss of time, and besides extra expenditure entailed in excavation, an additional quantity of clay puddle was required to fill up the widened trench. At the level of about 5 feet above the top of the rock the width of the puddle was decreased to practically the contract width, the space between this puddle and the sides of the trench as widened being filled with carefully selected material laid in thin layers and well rammed. Soon after beginning work at the reservoir, the new contractor erected a cableway across the valley of the Talla along the line of the centre of the embankment. The span was 1,500 feet, and the dip with the load at the centre was about 40 feet. The cableway was used to some extent for removing excavation from the trench, but much more for depositing puddle in the trench and wall. The clay, which was brought from Carluke by rail, a distance of about 32 miles, was emptied from wagons at depots which were formed from time to time at convenient elevations on the hillside at the east end of the embankment. The clay was then hand-soured until it was in proper condition for putting into the trench, when it was deposited there either with the aid of the cableway or by means of timber shoots arranged with sufficient incline from the clay-depot to the trench or wall. The shoots were fitted with trap-doors at intervals, so that clay could be dropped where required. The clay was then carefully cut into layers by men using lynching-tools. About 70 cubic yards of puddle were put in place by the cableway in a good day's work, each load being about 2 cubic yards. On the other hand, each shoot was found to be capable of delivering about 90 cubic yards in a day.

One accident unfortunately occurred during the 4 years the cableway was in use, the snapping of the "button rope" resulting in the death of two men and serious injury to others. On examination it was found that the rope had given way at a point where it passed over a small pulley at the top of one of the masts, and a chain was thereafter substituted for the wire-rope at this place. At the same time several whole-timber needles were placed across the trench at intervals of about 100 feet, in order that the men in the trench might be protected from any future failure of the cableway-ropes. The schedule rate for puddle in the trench and wall was 10*s.* per cubic yard. This included the cost of railway-carriage, which was 2*s.*, so that 8*s.* remained to cover royalties, handling, haulage up the private railway, alterations of sidings and puddle-depots from time to time, and contractors' profit. Fig. 2, Plate 3, is a longitudinal section of the puddle-trench, showing the proposed bottom of the trench and also the depth to which the excavation was actually carried. It also shows extensions at the ends of the trench, in each of which a quantity of concrete was used. Fig. 4 is a typical cross section of the embankment; and attention may be drawn to the flat inner slope. With the exception of some excavation at and near the waste-weir channel and the puddle wall, practically the whole of the material used in the formation of the embankment came from below the top water-level of the reservoir, and so contributed to the storage-capacity. The material was excavated by steam-navvies and brought up to the embankment by locomotive engines drawing wagons holding 4 to 5 cubic yards. The gauge of the rails was 4 feet 8½ inches throughout. The wagons were emptied on the surface of the embankment and the material was spread out in layers, the wagon-roads being slued from side to side of the embankment as required, thus contributing to its consolidation.

Outlet-Works.—As already stated, there are three shafts on the line of the outlet-tunnel. The inner shaft (Fig. 6, Plate 3), which contains the principal valves, stood for a long time with the lining completed to a height of a few feet above the extrados of the tunnel. Considerable quantities of water poured down the sides of the shaft on to the masonry and concrete backing. Before proceeding with the completion of the lining, careful observations were made of the water, and it was noticed that less water appeared to drop into the tunnel than passed down the shaft from above. The annular space 2 feet deep behind the top course of ashlar facing, which had not been backed with concrete, was then filled with water, while at the same time the water coming down the shaft was carefully excluded from this space. It was found that the water in the annular space very soon disappeared. In order to locate the particular spot at which it might be getting away, the space was divided into several compartments by concrete ribs 6 inches thick. These compartments were then filled with water and carefully watched, when it was found that the compartments over the line of the tunnel lost water much more quickly than the others. As the water was not finding its way into the tunnel, this experiment indicated that it was getting away outside the brick lining of the tunnel. An opening was accordingly made on the top of the tunnel at a short distance from the shaft, where it was found that when the excavation came within 5 or 6 feet of the extrados of the tunnel no explosives were required, as the rock had been sufficiently shattered by the explosives used in driving the tunnel originally. Instead of exposing the top of the tunnel any further, the expedient was resorted to of forcing Arden lime grout under pressure into the shattered rock and any vacant space there might be outside the tunnel-lining in the neighbourhood of the length exposed. This was done by inserting and carefully building in three 1½-inch diameter pipes about 6 feet long in the cavity between the lining and the rock, about 320 gallons of Arden lime grout being injected through them. Some of the grout was forced through the joints in the rock above the tunnel to a height of several feet and made its appearance in the sides of the excavation on the top of the tunnel. When it was found after several days that no more grout could be forced in, the excavated space on the top of the tunnel was filled with puddle to a height of 20 feet, the remainder of the cutting being filled with ordinary soft material. In view of this experience of the openness of the rock outside the tunnel-lining, it was decided to extend the puddle-trench right up to the centre shaft, in order to avoid the chance of water being lost from the reservoir by passing along the outside of the lining of the tunnel. The concrete carrying the waste-weir channel across the puddle-trench was accordingly continued up to and round the centre shaft and into the solid rock on the other side of it. The excavation round the shaft was carried on from within the shaft and from the bottom upwards, so as to avoid the expense and delay that would have been involved by sinking from the surface. Only very small charges of explosives were permitted to be used, and the concrete was carried up in stages after sufficient excavation had been removed.

When the works were otherwise far enough advanced to commence storing water, arrangements were made for building the brick plug in the outlet-tunnel at the inner shaft (Fig. 6). A recess had been left in the brick lining of the tunnel to receive the plug, which was built entirely of blue brick and occupied a length of 18 feet in the tunnel. Immediately in front of the plug, grooves for stop-planks had been left, and a puddle stank was erected there about 5 feet high. A timber trough was arranged to carry the flood-water from the top of the puddle stank over and beyond the site of the plug. The trough was about 6 feet wide and practically occupied one side of the tunnel. The valves were then set, also the compensation-pipe round which the plug was to be built. Unfortunately the work of building the plug could not be started until the month of March, and in its early stages the work was frequently interrupted by floods. After the compensation-pipe had been fixed, the brickwork was begun and carried up above the level of the top of this pipe, to the level at which the 36-inch supply-pipe is laid. Before the latter was set the trough was removed, and the water after overflowing the stank passed through the compensation-pipe. Several times, however, on account of the limited head then available, the compensation-pipe proved insufficient to deal with all the water, which accordingly rose over the brickwork, washing out a considerable amount of cement from the joints, and necessitating the taking down and rebuilding of several courses of brickwork. The bottom length of the standpipe was then set in its permanent position. The commanding valves on the supply-pipe were also fixed, and connected by means of an expansion-joint to the bottom length of the upstand. At the same time the 36-inch supply-pipe was placed on the brickwork of the plug which had previously been carried up to the proper height to receive it. Before building the remainder of the plug, the whole of the stop-planks and puddle were carefully removed, and any material left in the tunnel between the grating at the inlet and the plug, which might have prevented the proper closing of the valves, was taken away. No further trouble was experienced during the completion of the plug, because of the additional waterway provided by the supply-pipe and because the inner half of the plug was keyed first, which permitted of putting additional head upon the two pipes. The outer portion of the plug was shortly thereafter keyed, and it has proved to be quite water-tight with a head of more than 80 feet upon it.

The inner shaft is 15 feet in inside diameter, and is lined with cast-iron plates $1\frac{1}{8}$ inch thick from the top of the masonry upwards, so as to be perfectly water-tight. Outside the cast-iron lining, below ground-level, the shaft is lined with concrete; but above the surface of the ground the tower is built with parpend whinstone ashlar, 21 inches thick, set closely round the iron lining and well grouted in (Fig. 6, Plate 3).

The upstand pipe in the inner shaft (Fig. 6) is 48 inches in diameter and 82 feet 6 inches high. It is made of cast iron in lengths of about 6 feet, the thickness of metal ranging from 2 inches at the bottom to $1\frac{1}{4}$ inch at the top. The bottom length is made with three branches for connecting to the 36-inch supply-pipe already referred to, and to the two 36-inch pipes which are laid side by side along the tunnel on rolled steel beams, 9 inches by 7 inches, placed on cast-iron brackets bolted to the brickwork. Small adjustable cast-iron brackets are bolted on the beams to keep the pipes in position. Light longitudinal beams laid along the tunnel are also carried on the cross beams, which in turn carry a timber platform by means of which access is readily obtained to the pipes.

The pipes laid in the tunnel are all cast-iron tubes. They are jointed with light steel collars outside the plug at the centre shaft, and with heavy cast-iron collars between the plugs. The tubes are in 12-foot lengths, except at the curves, where they are in 6-foot lengths. One of the rolled-steel beams referred to is placed at each joint. The supply-pipe and the compensation-pipe are fitted with 36-inch sluice-valves in duplicate, made entirely of gun-metal, one being worked by hydraulic power and the other by hand from a worm-gear headstock, to provide against any failure of the hydraulic power. Failure of the water-supply, or accident to the hydraulic main, is provided against by a hand force-pump.

The gun-metal sluice-valves are made with parallel faces. The rods are of gun-metal, 4 inches in diameter: they are cast hollow in varying lengths and jointed together by gun-metal couplings with right- and left-handed screws, secured by tapered pins and working through cast-iron guide-brackets bushed with gun-metal and secured to cast-iron cross girders provided for that purpose. There are three 24-inch branches connected with the cast-iron upstand for drawing off water at various levels, namely, 7, 23, and 51 feet below top water-level.

The inlets have gratings at the outer ends made of wrought-iron bars fitted on a cast-iron cover upon the bellmouth pipe, made so that the gratings can be withdrawn at any time and replaced by gun-metal pot-lid valves so as to shut off water for the repair of the sluice-valves inside the tower. Three winches, placed on the outside of the tower-house, are provided for lifting the gratings and pot-lid valves, the latter being fitted with small valves to relieve pressure before lifting. The 24-inch sluice-valves on these branches are made entirely of gun-metal and worked by hydraulic power, having gun-metal rods, etc., similar in every respect to the 36-inch valves on the outlet and compensation. Each 36-inch gun-metal valve cost £350, and each 24-inch valve £165. At each 24-inch draw-off valve platforms are provided to give access for repairs, etc. They consist of cast-iron plates of open chequered pattern supported on cast-iron girders fixed to the cast-iron lining of the tower. The ladders giving access to the platforms are made with sides of wrought iron, convex in section, the treads being of forged brass. With regard to the treads of the ladders and the bolts, etc., being made of gun-metal, it may be mentioned that trouble had been experienced at the Gladhouse reservoir, where, after being in use about 20 years, all the wrought-iron rods, and the bolts and the treads of the ladders in the valve-shaft, had had to be replaced by forged brass.

The hydraulic cylinders for working the valves are of cast iron lined with gun-metal, and are supported on four pillars mounted on cast-iron sole-plates bolted to girders. The pistons are of gun-metal cast solid; they are fitted with gutta-percha packing rings, and secured to the piston-rods by means of nuts. Locking-clips are provided to grip the valve-rods and so retain the valves in and desired position. Brass indicators are connected with the valves to indicate the extent to which they are open. The power-water for working the hydraulic cylinders is conveyed in a 4-inch cast-iron main from a storage-tank situated in a glen about 2 miles from the tower and about 550 feet above the top water-level of the reservoir. A 2-inch wrought-iron pipe with flanges screwed on is taken off the main and carried across the gangway in duplicate lines and round the inside of the tower. There are two valves on this pipe inside the tower, one on each line of pipes on either side of the gangway, so that if a burst should occur on one line of pipe a valve can be shut down and the other line utilized. A $\frac{3}{4}$-inch copper tube connected to a four-way cock on the hydraulic cylinders is led overhead and provided with a stop-cock where it joins the main. The floor round the hydraulic cylinders in the tower is composed of cast-iron chequered plates, cast solid, and supported on cast-iron girders bolted to the lining of the tower. All bolts used in connection with the work in the various shafts are of forged brass with gun-metal nuts.

A second brick plug is built in the tunnel at the centre shaft, where there are three 36-inch sluice-valves, two on the supply-pipe, and one on the compensation-pipe. The object of the second plug and the valves is to enable the water to be controlled in the event of any accident happening to the plug or valves at the inner shaft, or to the pipes between the inner and centre shafts. The valves on the supply-pipes are, like those at the inner shaft, made entirely of gun-metal, and worked by hydraulic power. The valve on the compensation-pipe, however, has a cast-iron body, though the wedge is of gun-metal. It also is worked by hydraulic power. The gun-metal rods, guide-brackets, platforms, and ladders are similar to those already described for the inner shaft. From the centre shaft to the measuring-house only one line of pipes has been laid, as this part of the tunnel is accessible from an open end. The compensation-water runs in the bottom of the tunnel below the supply-pipes. At the outer shaft the pipes leave the tunnel, and run direct to the measuring-house. The upstand pipe at the outer shaft is cast iron and about 25 feet high, made in lengths of about 6 feet. There is also an 18-inch sluice-valve of cast iron, worked by a worm-gear headstock for scouring. A second upstand will be erected when the second line of pipes is laid.

The walls of the measuring- and screening-house are built of brickwork, faced with red Accrington bricks, while the upper house is built of Dumfriesshire red sandstone, with a roof of Arbroath pavement carried by steel trusses. The chamber is divided by a wall on which three gun-metal weirs are fixed, each 6 feet in length. A baffle, consisting of teak planks with an iron grating at the bottom, is placed across the first chamber to still the water as much as possible before it passes over the weirs. An integrating instrument of the Hutchison pattern is placed in the chamber to record the quantity of water passing over the weirs. The formula according to which the cam has been designed was obtained by direct experiment, using the second chamber of the measuring-house as a measuring-basin. This second chamber was provided for screening. The screens are carried by cast-iron standards, set in a circle, and bolted to the foundations, and joined together at the top by cast-iron floor-plates, fitted with a hand-rail round the inside of the curve. There are two sets of screens, the outer set having four spaces per lineal inch, of ordinary square mesh. The inner screens are of woven copper wire 0·035 inch in diameter, having eighteen spaces per lineal inch, and with ribbon mesh. Each screen is 4 feet 6 inches high by 4 feet 3 inches wide, and is composed of a frame of wrought-iron galvanized angle-bars 2½ inches by 2½ inches, joined together at the corners with gun-metal knees. There is a tee-iron stiffener for the wire gauze across the centre, which is secured to the frame by gun-metal screws. There are three gun-metal stays in each frame supporting the wire gauze. Three grooves are provided in the cast-iron standards, so that before removing one set of screens, another set can be put in place.

The available screening-area is 170 square feet. With a view to keep this area as large as possible, several planks are inserted in the aqueduct to raise the water-level in the screening-chamber, and so immerse a greater depth of screens. A small additional screening-well has been provided immediately to the north of the measuring-house for use at any time when it is necessary to shut off the water from the measuring-house for cleaning purposes or otherwise. A by-pass pipe is laid round the measuring-house into the small screening-well, and another by-pass is laid on the other side to the aqueduct beyond the screening-well, to allow of it also being cleaned out when necessary. It is only in this last contingency that water will be sent into the aqueduct without being screened. Both by-passes and the inlet-pipe to the measuring-house are fitted with 36-inch cast-iron sluice-valves, with gun-metal faces, worked by pillar and screw headstocks. A 36-inch pipe, fitted with a plain flange, has been built through the wall of the measuring-house to provide for the completion of the second line of pipes from the centre shaft when required. For lifting the screens and baffle-plates there is an overhead travelling gantry fitted with blocks.

The waste-weir of the reservoir is 200 feet long, and the crest is built of granite in lengths of not less than 3 feet, axed on the exposed faces, rounded on the front and back arrises, and weathered to take off the water. The cost of the granite was 6*s.* per cubic foot. The channel gradually narrows to a width of 40 feet, and, with the exception of one or two courses of granite near the waste-weir, the bottom of the channel is protected by 12-inch squared pitching set on concrete with deep courses at intervals. The walls are built of squared freestone rubble, and the public road is carried across the channel by an arched bridge of two spans, built of concrete and faced with ashlar.

Near the point where the waste-weir channel and the outlet-tunnel join the old course of the Talla Water a test-basin has been constructed in order that persons interested in the compensation-water may go up at any reasonable time and ascertain for themselves by direct measurement what quantity is being sent down. The test-basin between two fixed levels holds about 10,000 gallons, which is just the quantity of compensation-water that should be given in a period of 3 minutes. The chamber is divided into two compartments, one of which is divided by a thin partition of brickwork with a number of open beds and joints. The rush of the water in passing through this partition is stilled before it arrives at a square gun-metal orifice in the dividing wall between the two compartments. The water then in the ordinary course enters a trough in which it runs into the stream. The trough is fitted with a tumbling-bay, so that in an instant the water can be turned into the test-basin. A recorder has been placed to show that the head on the orifice is kept constantly to the true level determined by experiment. The walls of the test-basin are built of concrete faced with Accrington red bricks on the inside and with rubble masonry on the outside. The compensation-water is conveyed to the test-basin in a 24-inch cast-iron pipe from a small dam which has been built at the outer end of the tunnel. The whole cost of the basin, including the weir at the tunnel-mouth and the piping from there, was about £2,200. It was constructed in accordance with plans approved by Mr. B. Hall Blyth, M. Inst. C.E., acting on behalf of the River Tweed Commissioners, etc.

The Aqueduct.

Until shortly before the Trustees decided to go to Parliament in 1894, it was intended, as may be seen from Fig. 1, Plate 3, that from whichever source the additional supply was to be taken it should be delivered at the Trustees' existing works at Alnwickhill and filtered there. In the autumn of 1894 a change was decided upon in the place of delivery for the following reasons: (1) It was inexpedient to have most of the Trustees' important mains laid side by side over a mineral field in regard to which complicated legal questions had shortly before been raised. (2) The ground-level at Fairmilehead (about 2 miles to the west of Alnwickhill) was nearly 200 feet higher, and accordingly works constructed there would be at a more convenient elevation than those at Alnwickhill for maintaining constant service to various high-lying places in or near the city boundary.

The parliamentary plans of 1894 accordingly included a proposed service-reservoir, together with filters and a pure-water tank at Fairmilehead. These works, which are estimated to cost about £160,000, have not yet been constructed. Meanwhile the water, although brought near to Fairmilehead, is led past to Alnwickhill and filtered there.

The total length of aqueduct between the measuring-house at Talla reservoir and Alnwickhill filters is about 35 miles, including 9 miles of tunnel and about 12 miles of built aqueduct in cut and cover, the remainder being cast-iron piping. There are altogether twenty-one tunnels (exclusive of the outlet-tunnel from the reservoir) the shortest of which is about 133 yards in length, and the longest $1\frac{1}{3}$ mile. The longitudinal section (Fig. 7, Plate 3) shows the relative positions and lengths of the various tunnels, etc. As the extent of the tunnelling has given rise to considerable discussion, reference is made to this question later on.

Tunnels.—The material through which the tunnels were driven varied considerably—from hard rock, mainly greywacke, in the case of the tunnels in the Tweed valley between the reservoir and Broughton, to clay and running sand in the tunnels near Penicuik, one of which was driven with the aid of compressed air without a shield. The work of driving several of the tunnels was carried out by both night and day shifts, and the best progress made in driving through the hard rock was about 48 lineal yards per month. To attain this rate of progress required the use of very considerable quantities of the higher explosives. In fact, on 4 miles of tunnel in the sides of the hills in the Tweed valley nearly 70 tons of gelignite, costing upwards of £4,600, were used. In one of the tunnels very little blasting was required, and it was found that the mouths of most of the tunnels were in fairly open material. For a length through hard rock, the cost of explosives, fuses, and detonators worked out at nearly £1 sterling per lineal yard, or about 3*s.* per cubic yard of excavation.

The holes, which were drilled to a depth of 3 to 4 feet, were slightly inclined towards the true centre of the tunnel. The slow progress at many headings in the rock tunnelling was very disappointing, nor was it entirely justified by the water met with at the different places.

At first it was proposed to line only portions of the tunnels, but observation showed the desirability of lining all the tunnels, even including those which had been driven through the hardest rock. Much of the rock which was encountered in the tunnels was lying at a fairly high angle and the use of explosives had to some extent shattered rock beyond the required size, with the result that falls from the roof took place from time to time.

Having regard to the fact that the Trustees had at this time decided to delay the construction of the service-reservoir near Edinburgh, and taking into consideration the trouble which might be experienced in getting access to the tunnels to line them after the new works had been brought into operation and the contractor's plant taken away, the Author advised the Trust to proceed at once with the complete lining of all the tunnels. In this he was supported by Mr. G. H. Hill, M. Inst. C.E., and it was eventually arranged that this work should be proceeded with. In view of the interruptions which have taken place in other water-supplies through falls from the roof and sides, there can be little doubt that the proper course was adopted. In one tunnel about 11 miles south of the filters, where the material changed very quickly, but where occasionally great thicknesses of limestone were passed through, the concrete lining was necessary, if only to prevent the Talla water from being hardened by washing against the limestone for a length of 1 or 2 miles.

Cut-and-Cover Work.—The strata encountered on the line of the aqueduct in cut and cover, about 12 miles to the north of the reservoir, consisted of sand, gravel, and clay. When the cuttings were not kept free from water, this material, whenever it was disturbed, became semi-liquid. In order to prevent this, 9-inch fireclay tubes were laid in the bottom of the cutting before the concrete was put in. The tubes being laid upon and carefully surrounded with broken stones fully half-way up, a piece of felt was placed over the top half of each joint to prevent the concrete from getting into and filling the tubes.

At distances of about 150 feet sumps were placed, so that the pipes could be regularly cleaned out by means of brushes. The wet and spongy nature of the ground to be passed through at Mount Bog, for a length of about $\frac{3}{4}$ mile, rendered it very desirable to carry out the work during the summer months. A beginning was made in the bog after the aqueduct had been completed both to the north and to the south of the bog so as to afford facilities for getting rid of water. The work was started in May and completed in August, 1903. It was carried on day and night from both ends of the bog and in each direction from the centre. The water pumped in this length amounted to 350,000 gallons per day. Nine-inch fireclay tubes similar to those described above were laid in the bottom of the cutting directly under the invert, having the same fall as the aqueduct (1 in 4,000). Figs. 8, Plate 3, are typical cross sections of the concrete lining adopted in tunnel and in cut-and-cover work.

Tunnelling.—Work of an interesting nature was carried out in tunnels through the Penicuik estate, about 25 miles from the reservoir. Here the centre-line of the aqueduct was purposely deviated by the Trustees Act of 1898 in order to meet objections which the Penicuik Estate Trustees had made to the originally proposed line of aqueduct in cut and cover. There were four tunnels, 745, 1,036, 728, and 490 yards in length respectively, which passed through very varying strata and each of which required some special provision. From an early stage, having regard to the material passed through, and the suddenness with which it changed, steps were taken to keep the completed lining close up to the working-face. While one length was in solid freestone, the next lengths might be in coal and fireclay, or in running sand. The running sand in the bottom of the tunnel was at some places a source of considerable annoyance, but the driving of timber sheeting along the face of the foundations for the side walls prevented the foot-blocks carrying the side trees from being displaced before the invert was in. Iron plates $\frac{1}{4}$ inch thick, such as have frequently been used in underpinning houses in similar material, were tried in lieu of timber sheeting, but the limited depth which had to be driven told in favour of timber. Only one of the four tunnels just referred to was completely lined with concrete. Another was lined almost entirely with brickwork, nearly on the lines shown in Fig. 9, Plate 3. About one-third of the other two tunnels was also lined with brickwork of a similar section. Provision had been made originally for the great bulk of the lining being effected with concrete, and the change to brickwork in each case was brought about by the nature of the ground passed through. A marked objection to concrete lining in small tunnels through soft ground is the practical difficulty in preventing cavities from being left outside the lining, which may result in subsidence of the ground which will set up uneven strains in the lining. Brickwork, though considerably more expensive, is in every way much more reliable than concrete. With brickwork there is of course less difficulty in removing temporary timbering than with concrete. One great drawback to the use of brickwork in a small tunnel through bad ground is that unless work is proceeding at several faces there are long intervals between the times at which the bricklayers are required. Good men cannot be retained on such conditions without payment out of proportion to the work actually performed, while on the other hand the work of bricklayers brought to the spot only when occasionally required cannot be really satisfactory. In the beginning, the contractor had adopted the method of timbering by square settings, but, when concrete gave place to brickwork, timbering by long bars was adopted instead, and, as a result, much less trouble was experienced in the removal of the timber.

When the Carsewell tunnel had been driven and lined 80 yards at the south end and 60 yards at the north end, the rate of progress had become so slow that it was seen that, unless very special efforts were made, the remaining 588 yards would not be driven through and lined until long after the whole of the remaining works in connection with the Talla scheme had been completed. Owing to the ever-increasing demand for water this would have been a most unfortunate matter for the Trustees, who had shortly before passed through a very dry season and had experienced great difficulty in maintaining a full supply. They did not look with favour on a proposal that they should take the work of driving and lining the remainder of the tunnel into their own hands, but after consideration they arranged with the contractor a new basis of payment, and he thereafter proceeded to carry on the work with the aid of compressed air, but without a shield. The new basis of payment, besides being more liberal than bare contract prices, also provided for a bonus applicable at certain stages of the work so as to ensure its completion without further delay. For some time before the new arrangement was entered into, little or no progress had been made at either face. After fitting up the compressed-air plant about to be described, which was, in the first instance, used for forcing grout into cavities behind the work already completed, in order to prevent the escape of the compressed air, substantial progress began to be made. It was found that the excavation for a 9-foot length could be taken out in about 30 hours and the brick lining built in about 18 hours (Fig. 9).

A small top heading was always kept sufficiently in advance of an excavated length to permit of drawing forward the crown-bars from a length in course of being built. Two crown-bars (alternating as usual with one crown-bar in successive lengths) were placed in position to carry the head-trees and roof of the top heading; the side trees were then removed with the exception of those in the leading setting, the crown-bars being supported on a temporary horse-head and on the top of the last length of brickwork. As the excavation was widened, two more bars were inserted to carry the poling-boards which supported the roof, care being taken at this stage to pack any cavity with timber, clay, bricks, etc., as found convenient. Stable-refuse was largely used in some places where an inflow of water seemed likely to bring fine silt with it. The nipper-sill was then introduced and the horse-head removed. In heavier ground than that just referred to, three 12-inch by 6-inch beams close together were used in place of a single crown-bar. Occasionally it was found practicable to draw one or other of these bars. They were, however, kept high enough at the leading end in the first instance to allow for a slight drop, and still permit the placing of the bars of the next length underneath them and outside the four rings of brickwork. Heavier poling-boards were also used. Each bar was temporarily propped from the nipper-sill until the heading was sufficiently wide to get in the main sill. This sill was prevented from moving laterally by two stretchers, which were only removed when the brickwork had been carried up to such a height that the sill could be strutted from it by short temporary stretchers. It was frequently found necessary to timber below the springing-level of the tunnel as well as at the face. As usual in such cases of tunnelling, care was taken to smear the surface of the poling-boards carefully with clay so as to prevent an undue loss of compressed air. The brickwork was built in lengths of 9 feet, and when the excavation had been taken out, the bricklayers, who were in readiness, immediately began to thoroughly scrape and clean the toothing of the old brickwork preparatory to starting the new length. The brick invert and the skew-backs were laid in the first instance, a sump being left in the invert from which the water was baled during the building of the length. Four rings of brickwork were put in, the space between the back ring and the poling-boards being packed with brick in cement. The facing was of red Accrington brick, and radiated bricks were used in the arch. The amount of brickwork per lineal yard, including packing, averaged about 6 cubic yards: about 5,000 bricks, 4 tons of sand, and 2 tons of cement were used in a 9-foot length. The air-pressure at the south end ranged from about 10 lbs. to 19 lbs. per square inch, and was maintained by two Larmuth single-cylinder compressors, 12 inches in diameter and 18 inches stroke, the steam- and air-cylinders being of the same dimensions. The compressors ran at 50 to 60 revolutions per minute and delivered into a receiver of about 600 or 700 cubic feet capacity. The locks in the tunnel consisted of cast-iron cylinders, about 5 feet in inside diameter and about 15 feet long, in three sections, so that they might be easily brought in through the concrete lining already built. The different sections were bolted together with outside flanges which were built into temporary brickwork. This was afterwards removed, together with the lock, before the permanent lining was put in place. The weight of the rails generally used in the tunnels was 16 lbs. per lineal yard. The skips which were used to convey the concrete material from the mixing-shed outside the tunnel to the face were 3 feet 6 inches long by 2 feet wide by 1 foot 4 inches deep, inside measure, and they held 10 to 12 cubic feet. This size of skip was used for all purposes in the compressed-air tunnel, being limited by the size of the air-lock doors. In the other tunnels larger skips, 4 feet 3 inches by 3 feet 3 inches by 1 foot 6 inches deep inside measure, holding about $\frac{3}{4}$ cubic yard, were used for removing the excavations from the face. Horses were used for dragging the skips in the tunnels, except in the case of the compressed-air tunnel, where the skips were pushed on trollies by the men.

Before the faces met, the work of driving the north end was suspended, and the plant there dismantled. A curious circumstance was noticed, namely, that the compressed air escaping through the ground from the south working-face was sufficient to close the air-lock doors at the northern face, notwithstanding the fact that the north and south faces were at the time about 70 yards apart. The air-locks at the north and south ends were about 550 yards apart. The ground passed through in the Carsewell tunnel was not uniformly bad, and hard boulder clay was occasionally encountered for a portion of the depth at the face. Blasting was then resorted to, and, while the brickwork was kept close up to the face of the excavation as formerly, great care was taken to protect the toothing of the heading end of the brickwork from injury.

In driving one tunnel through fairly good standing material, when the faces were about 200 yards from the tunnel-mouth, the air became so foul that it was necessary to put down tube-bores into the tunnel from the surface of the ground. Occasionally even these bores, which were $2\frac{1}{2}$ inches in diameter, were insufficient, and it became necessary to hang lights below them to assist ventilation. In this connection it may be mentioned that the driving of the rock tunnels could be carried on by hand only for a short distance owing to the air at the face becoming foul. When, however, machine-drills were used, the exhaust air from the machines kept the atmosphere good. It was the general practice to fire a round of shots immediately before a meal-hour, during which time the air-pipe was disconnected from the machine, and discharged air into the face, soon dispersing the fumes caused by the explosives.

In the tunnel at 21 miles from the reservoir the rock passed through for the first 400 yards or so was comparatively dry, and little provision was accordingly required for carrying off the water. This tunnel required lining at an early stage. Shortly afterwards, however, considerable quantities of water were encountered, partly perhaps on account of old mineral-workings in the neighbourhood. This water, which considerably interfered with the driving, was troublesome to dispose of. The method ultimately adopted for getting rid of it was to erect a small stank at the end of the completed lining, nearest the face, and pump the water over it. This, however, entailed the raising of the tramroad by means of timber props from the outer end of the tunnel to clear the top of the stank. The total quantity of water met with in this tunnel and in that immediately to the north, a length of about 2 miles, amounted in a period of dry weather to about half a million gallons per day. When the lining had been put in, the water was led through the walls in pipes, so as to relieve the pressure behind the walls. Unfortunately this water contained a great deal of iron, large quantities of iron oxide being precipitated inside the tunnel. Moreover a great deal of the water which entered the tunnel was very hard, having come from the limestone rock through which a considerable portion of the tunnel was driven. As it was feared that so large a quantity of hard and irony water might appreciably affect the quality of the Talla water, it was decided to intercept this hard water, and to lead it out of the tunnel altogether. For this purpose cast-iron turned and bored pipes were laid in the tunnel close to one of the side walls, and, as far as possible, all the water entering the tunnel was caught up and connected to these pipes. The irony water was discharged at both the north and south ends of the tunnel, the iron pipes being laid with a fall in both directions from the summit, which was about 1,000 yards from the south end. As the pipes discharging at the south end were laid with a gradient opposite to that of the invert of the aqueduct, they had to be supported by concrete piers built to the proper level. On the other hand, the pipes discharging at the north end were laid at the same gradient as the invert of the aqueduct. The pipes gradually decreased in diameter from 15 inches at the lower to 6 inches at the upper end, and the whole of the pipes, 4,360 lineal yards, were obtained and laid, and all the connections were made, in the course of 3 months. Hatch-boxes were placed on the pipes at intervals of about 200 feet to allow of the pipes being cleaned out when necessary. Expansion-joints were also inserted to provide for fluctuations of temperature. In view of certain industries on the stream into which the waste water is discharged, a series of rough settling-tanks fitted with screens of small mesh have been constructed.

It was the contractor's intention to use broken limestone obtained from the excavations for the concrete lining. In view, however, of the experience of the wasting away of limestone by soft water in a concrete aqueduct at another place it was decided to use whinstone metal from a neighbouring quarry.

Cost of the Works.

The whole cost of the Talla scheme up to the present date has been about £1,250,000, including works, land, way-leaves, engineering, inspection, and the various parliamentary and legal expenses. The aqueduct as constructed is much larger than was originally proposed. It has cost about £750,000, and where in tunnel or cut and cover with a gradient of 1 in 4,000 it will not only be able to exhaust the Talla drainage-area but will also provide for conveying, in future years, water from some of the other tributaries of the Tweed. Having regard to this provision for the future, the Trustees claimed and obtained from Parliament the somewhat unusual power to suspend the application of the sinking-fund for a number of years. The aqueduct has already brought in water at the rate of 11 million gallons per day, but no opportunity has yet been afforded of testing it to its full carrying-capacity, which is of course limited by the cast-iron siphons.

As already mentioned, some objection has been taken to the expenditure of money upon tunnels at various points along the line of the aqueduct, and particularly through the hills alongside the Tweed valley. It has been suggested that the first seven tunnels, representing a length of about 4 miles, should have been entirely dispensed with and cast-iron piping adopted instead, either along the line of the public road or along the line of the railway. In order that effect might be given to either of these proposals, the construction of a siphon at least 8 miles in length with a diameter of not less than 33 inches would have been involved. Such a siphon would have been sufficient, as a portion of the whole aqueduct, to bring in 8 million gallons of water daily, which was the originally anticipated quantity available from the Talla drainage-area. The rain-gauge arbitrators have, however, clearly brought out that in ordinarily dry years practically 10 million gallons per day will be available for town consumption after full compensation has been given. It is therefore evident that if the 33-inch siphon only had been laid in the first instance it would not have exhausted the yield of the Talla drainage-area. No new service-reservoir having yet been provided near the city, it is of consequence that the new aqueduct should be able occasionally to bring in considerably more than merely the average yield. An estimate, made about 12 years ago in connection with a proposal to construct an aqueduct into Edinburgh from Talla, mainly of cast-iron pipe and with only a short length of tunnel, brought the probable cost out at over £400,000. This aqueduct would have been capable of bringing in only 8 million gallons per day, and it comprised so short a length of tunnel that practically the whole expenditure would have had to be incurred again in connection with each further instalment of 8 million gallons per day. Besides this, the estimate was based upon cast-iron pipes at £5 per ton, while higher prices have been paid by the Trustees since that date for large piping.

A siphon of considerable length under high pressure may be somewhat expensive to maintain, and it has been the Trustees' experience, in connection with a length of about a mile on one of the present Talla siphons where the pressure is highest, that the water-logged nature of the ground passed through was not suitable either for pipe-laying in the first instance, or for the subsequent detection of leakage. Assuming that tunnelling was adopted only where absolutely necessary to pass through a watershed, at least three lines of 48-inch pipe would become necessary to convey the

REVENUE FROM WATER-RATES.

—	**1870–71.** Shop Rate, 3*d.* per £1. Domestic Rate, 8*d.* per £1. Trade Rate, 9*d.* per 1,000 Gallons. No Public Rate.	**1904–05.** Shop Rate, 2*d.* per £1. Domestic Rate, 6½*d.* per £1. Trade Rate, 6*d.* per 1,000 Gallons. Public Rate, 1½*d.* per £1.	Increase of Revenue from Water-Rates between 1870–71 and 1904–05.
	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*
Domestic	30,849 9 6	56,109 8 11	25,259 19 5 = 81·88 per cent. increase.
Manufactories, shipping, etc.	12,022 11 8	52,612 18 7¾[1]	40,590 6 11¾ = 337·60 per cent. increase.
Public rate	..	20,466 17 5½	20,466 17 5½
Penalty for deferred payment	..	258 14 5	258 14 5
Arrears recovered	..	95 10 7	95 10 7
	42,872 1 2	129,543 10 0¼	86,671 8 10¼
Less repayments	31 17 8	8 9 0	23 8 8 (decrease).
Net amount of water-rates recovered	42,840 3 6	129,535 1 0¼	86,694 17 6¼

[1] Including meter supplies to Musselburgh, Dalkeith, etc.

whole supply available from the head-waters of the Tweed. The first application to Parliament by a water-authority for power to lay a large number of pipes on one narrow road has been frequently contested. Appendix III shows how comprehensive are the Trustees' present powers in regard to laying and duplicating mains.

The Table on p. 131 shows the revenue from the water-rates between the years 1870–71 and 1904–05.

The public water-rate of ½*d.* per £1 on rental was levied from Whitsunday, 1874, to Whitsunday, 1877, and thereafter, until Whitsunday, 1904, was increased to 1*d.* per £1. During the year to Whitsunday, 1905, this rate was again raised to 1½*d.* per £1.

While the domestic rate in 1870–71 was 8*d.* per £1, it never rose above 9*d.* per £1, and at present it stands at 6½*d.* per £1. From 1896–7 to 1903–4 it stood at only 5*d.* per £1.

CONCLUSION.

Altogether nearly fifty contracts have been entered into. This number is considerably larger than was originally contemplated, but several of the contracts in a partially completed state were taken and relet by the Trust after the death of two of the contractors.

Messrs. James Young and Sons, of Edinburgh, constructed the railway, and had made some progress with the reservoir prior to the death of their senior partner. Mr. Best, of Edinburgh and Leith, who had already in hand several portions of the aqueduct, about 14 miles in length, obtained the contract for the completion of the reservoir. Messrs. Robert McAlpine and Sons, of Glasgow, constructed another portion of the aqueduct about 10 miles in length. The laying and jointing of over 4 miles of piping was performed by workmen employed directly by the Trustees. Some of the pipe-laying was performed by the contractors already named, or by Messrs. Pollock, Harvie, etc. Other contracts were for the Trustees' house at Talla reservoir, and sluice-keepers' houses; for new road-bridges and widenings, and for fencing, as well as for pipes taking supplies to adjoining farms and estates, etc. Messrs. Glenfield and Kennedy, of Kilmarnock, supplied and erected the upstand pipes at the inner and outer shafts, and the gun-metal valves and hand and hydraulic apparatus at the reservoir-shafts for working them. They also provided and erected the automatic and ordinary valves and sluices in connection with the aqueduct.

The new waterworks were reported upon, and afterwards designed by, and constructed under the direction of, successive members of the firm of J. and A. Leslie and Reid, Civil Engineers, of Edinburgh (the late Messrs. Alexander Leslie, Robert Carstairs Reid, and James Wilson, and the Author and Mr. William Carstairs Reid). Mr. G. H. Hill, who reported with the late Messrs. Gale and Mansergh on the proposed additional water-supply, was retained as Consulting Engineer for the reservoir.

The Paper is accompanied by twenty-four drawings, from which the illustrations reproduced in Plate 3 have been selected, and by four photographs: also by the following Appendixes.

[Appendixes.

APPENDIX I.

EDINBURGH AND DISTRICT WATERWORKS (TALLA SCHEME).

Rainfall in 1896.

Gauge	Monthly Readings				Daily Readings			Average	Duplicate Gauges—Monthly Readings		
	No. 1	No. 2	No. 3	No. 4	No. 5a	No. 6a	No. 7a		No. 5	No. 6	No. 7
Position	At Meggat Head (Talla Moss)	At Loch Craig Head	At Ravenscraig	At Gameshope Loch	At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill		At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill
Ordnance Level	1496·05 Ft.	2627·34 Ft.	2258·28 Ft.	1859·92 Ft.	1537·59 Ft.	966·03 Ft.	1196·48 Ft.		1537·59 Ft.	966·03 Ft.	1196·48 Ft.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January	3·33	3·82	3·80	3·87	4·24	3·23	2·49	3·54	4·33	2·69	2·49
February	3·98	4·80	4·38	4·32	4·35	3·08	2·39	3·90	4·55	3·58	3·03
March	6·70	5·80	5·81	9·20	7·29	6·09	5·59	6·64	7·37	6·49	5·20
April	2·54	2·13	2·45	2·52	2·57	1·98	1·98	2·31	2·60	2·33	1·97
May	0·81	0·76	0·75[1]	0·93	0·70	0·54	0·75	0·75	0·70	0·60	0·75
June	5·80	6·05	5·25	5·90	6·05	5·26	3·98	5·47	6·07	5·50	4·24
July	6·87	7·23	7·45	7·40	7·25	5·92	5·07	6·74	7·34	5·98	4·80
August	3·52	3·62	4·10	4·33	4·09	2·84	2·70	3·60	4·15	2·98	2·70
September	7·87	9·13	8·97	9·98	9·91	7·10	5·20	8·31	10·05	7·35	5·25
October	6·18	4·29	4·54	6·15	6·69	6·82	5·00	5·67	6·83	7·21	5·11
November	2·58	2·45	2·24	2·77	3·05	2·43	1·69	2·46	3·00	2·88	1·59
December	8·73	8·50	8·15	10·28	10·78	8·55	6·15	8·73	11·05	8·65	6·25
Total	58·91	58·58	57·89	67·65	66·97	53·84	42·99	58·12	68·04	56·24	43·38

NOTE.—Gauges Nos. 1, 2, 3 and 4 are 8-inch brass-rimmed Casella (Snowdon) gauges, set 1 foot above ground.
Gauges Nos. 5a, 6a and 7a are 5-inch " " " " " " "
Gauges Nos. 5, 6 and 7 are Milne's zinc gauges, area 100 square inches, set 1 foot above ground.

JAMES WILSON.
B. HALL BLYTH.

[1] This gauge had been interfered with: the average of the other six gauges was taken as the proper amount for this month.

EDINBURGH AND DISTRICT WATERWORKS (TALLA SCHEME).

Rainfall in 1897.

Gauge	Monthly Readings				Daily Readings			Average	Duplicate Gauges—Monthly Readings		
	No. 1	**No. 2**	**No. 3**	**No. 4**	**No. 5a**	**No. 6a**	**No. 7a**		**No. 5**	**No. 6**	**No. 7**
Position	At Meggat Head (Talla Moss)	At Loch Craig Head	At Ravenscraig	At Gameshope Loch	At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill		At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill
Ordnance Level	1496·05 Ft.	2627·34 Ft.	2258·28 Ft.	1859·92 Ft.	1537·59 Ft.	966·03 Ft.	1196·48 Ft.		1537·59 Ft.	966·03 Ft.	1196·48 Ft.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January . .	2·40	(3·04)[1]	(2·32)[1]	2·07	3·00	2·91	1·85	2·51	3·03	2·88	1·74
February . .	6·02	(7·61)[1]	(5·83)[1]	6·62	8·21	6·36	3·56	6·31	8·25	6·48	3·90
March . .	9·37	(9·27)[1]	6·95	9·15	11·45	10·90	6·75	9·12	11·53	10·93	6·43
April . . .	5·12	(5·13)[1]	5·05	5·50	6·48	4·66	3·36	5·04	6·50	4·69	3.36
May . . .	3·72	3·95	3·76	3·96	3·89	3·35	2·31	3·56	4·00	3·37	2·54
June . . .	6·14	4·68	4·46	5·83	5·00	5·38	5·19	5·24	5·50	5·35	5·00
July . . .	4·25	5·55	4·45	4·50	4·71	4·18	3·56	4·46	4·75	4·28	3·55
August . .	10·00	12·48	13·30	13·54	12·64	10·12	6·96	11·29	12·65	10·20	7·32
September .	4·87	5·43	5·68	4·70	5·18	4·44	4·05	4·91	5·40	4·12	3·70
October . .	5·10	4·62	4·88	5·88	6·34	4·97	3·15	4·99	6·38	4·72	3·13
November .	4·96	6·80	7·40	6·61	6·63	5·10	4·21	5·96	6·68	5·21	4·20
December .	12·96	11·26	12·89	15·40	16·35	13·53	9·18	13·08	16·45	14·72	9·80
Total . .	74·91	79·82	76·97	83·76	89·88	75·90	54·13	76·47	91·12	76·95	54·67

[1] The gauges at Loch Craig Head and at Ravenscraig were found frozen at the end of January, and were not emptied till the end of February. The gauge at Lochcraighead was again found frozen at the end of March, and was not emptied till the end of April. In dividing the total amounts collected in these gauges for the two months, the average of the remaining gauges for each month was taken, and the total amounts collected for the two months were divided proportionally.

JAMES WILSON.
B. HALL BLYTH.

Edinburgh and District Waterworks (Talla Scheme).

Rainfall in 1898.

Gauge	Monthly Readings				Daily Readings			Average	Duplicate Gauges—Monthly Readings		
	No. 1	No. 2	No. 3	No. 4	No. 5a	No. 6a	No. 7a		No. 5	No. 6	No. 7
Position	At Meggat Head (Talla Moss)	At Loch Craig Head	At Ravenscraig	At Gameshope Loch	At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill		At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill
Ordnance Level	1496·05 Ft.	2627·34 Ft.	2258·28 Ft.	1859·92 Ft.	1537·59 Ft.	966·03 Ft.	1196·48 Ft.		1537·59 Ft.	966·03 Ft.	1196·48 Ft.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January . .	3·74	4·64	5·23	4·40	4·96	3·25	3·06	4·18	5·12	3·60	2·82
February . .	4·00	(3·37)[1]	(3.65)[1]	3·60	5·89	4·76	3·42	4·10	6·00	5·20	3·40
March . .	1·89	(1·58)[1]	(1·75)[1]	1·85	2·50	2·10	1·83	1·93	2·50	2·53	1·55
April . . .	6·80	(5·13)[1]	6·82	7·70	7·58	6·45	4·23	6·39	7·67	6·50	4·57
May . . .	2·95	2·51	2·87	2·87	2·91	2·89	2·85	2·84	3·11	3·03	2·81
June . . .	2·71	4·17	5·31	4·31	4·99	3·07	2·97	3·93	Leaking	3·00	2·80
July . . .	1·92	2·10	1·75	1·57	1·77	1·75	1·81	1·81	1·70	1·65	1·72
August . .	5·44	6·68	9·77	7·30	6·62	5·26	5·10	6·60	6·47	5·26	5·13
September .	5·63	5·80	6·39	5·50	6·24	5·55	4·32	5·63	6·03	5·55	4·35
October . .	6·18	7·58	7·06	8·92	8·93	7·30	6·28	7·46	8·53	7·30	6·00
November .	6·28	7·47	8·50	7·50	7·96	7·27	5·84	7·26	7·95	7·30	5·80
December .	5·30	12·10	11·75	9·70	10·83	9·12	7·62	9·49	10·85	9·13	7·14
Total .	52·84	63·13	70·85	65·22	71·18	58·77	49·33	61·62		60·05	48·09

[1] The gauges at Loch Craig Head and at Ravenscraig were found frozen at the end of February. The gauge at Ravenscraig was not emptied till the end of March, and the gauge at Lochcraighead was not emptied till the end of April. In dividing the total amounts collected in these gauges for these months, the average of the remaining gauges for each month was taken, and the total amounts collected were divided proportionally.

James Wilson.
B. Hall Blyth.

EDINBURGH AND DISTRICT WATERWORKS (TALLA SCHEME).

Rainfall in 1899.

Gauge	Monthly Readings No. 1	Monthly Readings No. 2	Monthly Readings No. 3	Monthly Readings No. 4	Daily Readings No. 5a	Daily Readings No. 6a	Daily Readings No. 7a	Average	Duplicate Gauges—Monthly Readings. No. 5	Duplicate Gauges—Monthly Readings. No. 6	Duplicate Gauges—Monthly Readings. No. 7
Position	At Meggat Head (Talla Moss)	At Loch Craig Head	At Ravenscraig	At Gameshope Loch	At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill		At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill
Ordnance Level	1496·05 Ft.	2627·34 Ft.	2258·28 Ft.	1859·92 Ft.	1537·59 Ft.	966·03 Ft.	1196·48 Ft.		1537·59 Ft.	966·03 Ft.	1196·48 Ft.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January	5·35	(7·50)[1]	(7·77)[1]	7·68	7·78	6·37	5·39	6·83	7·78	6·38	5·40
February	6·60	(6·36)[1]	(4·79)[1]	7·67	8·19	6·19	4·41	6·32	8·17	6·18	4·20
March	4·61	6·05	5·70	6·72	7·82	6·07	4·42	5·91	7·88	6·05	4·02
April	4·49	4·73	5·52	6·42	6·24	5·17	(4·25)[2]	5·26	6·25	5·23	4·33
May	3·83	4·78	4·81	5·08	5·57	4·35	3·55	4·57	5·60	4·34	2·93
June	1·73	(2·12)[3]	2·57	2·37	2·81	2·05	1·20	2·12	2·95	2·17	1·58
July	4·91	6·31	5·70	5·47	5·41	4·02	3·63	5·06	4·20	4·02	3·23
August	2·06	2·84	2·42	2·60	2·81	2·30	2·15	2·46	2·83	2·33	2·40
September	4·89	6·17	6·40	5·60	6·30	5·51	5·67	5·79	6·33	5·51	5·55
October	4·72	6·04	7·01	6·02	6·69	4·87	4·32	5·67	6·80	4·97	4·03
November	11·58	13·49	12·72	12·67	15·65	12·34	10·18	12·66	15·65	12·38	10·17
December	2·86	2·40	2·66	2·42	3·83	3·91	2·69	2·97	3·75	3·92	2·30
Total	57·63	68·79	68·07	70·72	79·10	63·15	51·86	65·62	78·19	63·48	50·14

[1] The gauges at Loch Craig Head and at Ravenscraig were found frozen at the end of January and were not emptied till the end of February. In dividing the total amounts collected in these gauges for the two months, the average of the remaining gauges in January was taken, and the remainder entered for February.

[2] The gauge at Quarter Hill was found to have been tampered with on the 10th April.

[3] The gauge at Loch Craig Head was found to have been tampered with, and the average of the remaining gauges for this month has been entered.

B. HALL BLYTH.
JAMES WILSON.

EDINBURGH AND DISTRICT WATERWORKS (TALLA SCHEME).

Rainfall in 1900.

Gauge	Monthly Readings				Daily Readings			Average	Duplicate Gauges—Monthly Readings		
	No. 1	**No. 2**	**No. 3**	**No. 4**	**No. 5a**	**No. 6a**	**No. 7a**		**No. 5**	**No. 6**	**No. 7**
Position	At Meggat Head (Talla Moss)	At Loch Craig Head	At Ravenscraig	At Gameshope Loch	At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill		At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill
Ordnance Level	1496·05 Ft.	2627·34 Ft.	2258·28 Ft.	1859·92 Ft.	1537·59 Ft.	966·03 Ft.	1196·48 Ft.		1537·59 Ft.	966·03 Ft.	1196·48 Ft
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January	5·45	7·00[1]	5·56[1]	6·00[1]	8·31	6·85	5·60	6·40	8·00	6·85	5·46
February	2·47	4·05[2]	1·64[3]	0·80	3·97	5·28	2·77	3·00	3·85	5·30	2·77
March	0·57	2·09[4]	0·17[4]	0·30	1·05	0·98	0·34	0·79	1·08	0·96	0·28
April	2.55	2·73	3·29	3·38	4·78	4·59	3·78	3·58	4·75	4·58	3·80
May	6·10	6·62	6·25	6·87	8·03	6·20	5·11	6·45	8·05	6·20	4·76
June	10·00	8·45	7·85	8·58	8·41	6·23	4·70	7·75	8·50	6·23	4·15
July	4·20	5·73	5·75	5·28	5·22	3·87	2·89	4·70	5·25	4·03	3·25
August	5·22	7·35	7·05	6·35	6·73	6·64	5·07	6·34	6·70	6·64	4·42
September	4·78	7·43	7·33	6·70	6·99	4·44	4·01	5·95	7·02	4·45	3·93
October	4·87	8·47	8·75	7·72	8·01	6·73	5·79	7·19	8·39	6·92	6·07
November	5·98	5·72	5·83	7·13	8·16	7·10	5·24	6·46	8·26	7·18	4·75
December	11·42	16·18	16·14	15·57	17·11	12·03	10·19	14·09	17·50	12·02	8·23
Total	63·61	81·82	75·61	74·68	86·77	70·94	55·49	72·70	87·35	71·36	51·87

[1] Gauges found frozen, not emptied.
[2] Gauge partly frozen and only the water found in the gauge emptied out.
[3] " " " " " "
[4] Gauges found frozen, not emptied.

B. HALL BLYTH.
W. A. TAIT.

EDINBURGH AND DISTRICT WATERWORKS (TALLA SCHEME).

Rainfall in 1901.

Gauge	Monthly Readings				Daily Readings			Average	Duplicate Gauges—Monthly Readings		
	No. 1	**No. 2**	**No. 3**	**No. 4**	**No. 5a**	**No. 6a**	**No. 7a**		**No. 5**	**No. 6**	**No. 7**
Position	At Meggat Head (Talla Moss)	At Loch Craig Head	At Ravenscraig	At Gameshope Loch	At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill		At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill
Ordnance Level	1496·05 Ft.	2627·34 Ft.	2258·28 Ft.	1859·92 Ft.	1537·59 Ft.	966·03 Ft.	1196·48 Ft.		1537·59 Ft.	966·03 Ft.	1196·48 Ft.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January . .	2·93	3·60	3·80	3·42	4·21	3·48	2·73	3·45	4·19	3·50	2·38
February .	2·22	2·27	2·38	2·15	3·33	2·28	1·82	2·35	3·65	2·69	2·11
March . .	2·92	3·25	2·37	2·12	4·17	4·04	2·36	3·03	4·26	4·02	1·80
April . . .	4·80	3·31	4·63	5·06	7·56	6·42	5·03	5·26	7·66	6·42	4·33
May . . .	2·43	3·27	2·98	3·28	1·96	3·02	1·98	2·70	1·92	2·98	1·80
June . . .	3·54	5·78	5·73	5·15	5·93	5·13	3·83	5·01	5·93	5·12	3·56
July . . .	1·08	1·68	1·98	1·99	1·96	1·44	1·37	1·64	2·03	1·61	1·22
August . .	4·75	7·75	5·37	8·15	8·35	7·09	6·15	6·80	8·30	7·05	5·26
September .	5·04	8·32	10·50	9·10	9·31	6·48	4·15	7·56	9·38	6·67	3·91
October . .	3·92	7·57	8·88	7·40	7·79	6·44	4·99	6·71	7·77	6·43	4·63
November .	3·18	4·13	4·38	3·42	4·33	4·98	3·67	4·01	4·35	4·98	2·95
December .	3·38	5·53	5·18	4·00	5·42	5·56	5·37	4·92	5·60	5·58	2·67
Total . .	40·19	56·46	58·18	55·24	64·32	56·36	43·45	53·44	65·04	57·05	36·62

B. HALL BLYTH.
W. A. TAIT.

EDINBURGH AND DISTRICT WATERWORKS (TALLA SCHEME).

Rainfall in 1902.

	MONTHLY READINGS				DAILY READINGS			Average	DUPLICATE GAUGES—MONTHLY READINGS		
Gauge	**No. 1**	**No. 2**	**No. 3**	**No. 4**	**No. 5a**	**No. 6a**	**No. 7a**		**No. 5**	**No. 6**	**No. 7**
Position	At Meggat Head (Talla Moss)	At Loch Craig Head	At Ravenscraig	At Gameshope Loch	At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill		At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill.
Ordnance Level	1496·05 Ft.	2627·34 Ft.	2258·28 Ft.	1859·92 Ft.	1537·59 Ft.	966·03 Ft.	1196·48 Ft.		1537·59 Ft.	966·03 Ft.	1196·48 Ft.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January . .	3·66	4·40	6·33	4·95	7·12	5·75	4 21	5·20	7·13	5·75	3·87
February .	1·73	2·95	1·87	1·65	2·26	2·26	0·94	1·95	2·22	2·30	0·90
March . .	3·45	4·05	4·05	3·68	4·99	3·47	2·45	3·74	5·05	3·40	2·75
April . .	3·90	4·00	4·00	4·41	4·86	4·76	3·60	4·22	4·87	4·77	3·60
May . . .	2·65	2·70	2·61	2·65	3·20	3·17	2·35	2·76	3·15	3·15	2·32
June . . .	1·30	1·98	1·88	1·79	1·78	1·51	1·16	1·63	1·78	1·45	1·27
July . . .	2·76	4·62	4·77	3·49	4·02	3·45	2·59	3·67	4·00	3·95	2·59
August . .	3·05	3·60	4·67	3·98	4·14	2·92	2·28	3·52	4·13	2·92	2·40
September .	3·79	4·83	4·07	4·38	4·53	4·19	3·19	4·14	4·53	4·18	3·02
October . .	5·27	4·37	5·10	4·87	5·14	3·66	3·05	4·49	5·13	3·66	3·05
November .	5·38	6·80	7·20	6·87	6·85	6·30	4·36	6·25	6·82	6·33	4·34
December .	8·55	5·81	8·04	7·74	10·36	9·63	6·19	8·05	10·38	9·62	6·24
Total . .	45·49	50·11	54·59	50·46	59·25	51·07	36·37	49·62	59·19	51·48	36·35

B. HALL BLYTH.
W. A. TAIT.

EDINBURGH AND DISTRICT WATERWORKS (TALLA SCHEME).

Rainfall in 1903.

Gauge	Monthly Readings.				Daily Readings.			Average	Duplicate Gauges—Monthly Readings.		
	No. 1	No. 2	No. 3	No. 4	No. 5a	No. 6a	No. 7a		No. 5	No. 6	No. 7
Position	At Meggat Head (Talla Moss)	At Loch Craig Head.	At Ravenscraig	At Gameshope Loch	At Gameshope Farm	At Talla Linns Foot Farm.	At Quarter Hill.		At Gameshope Farm.	At Talla Linns Foot Farm.	At Quarter Hill.
Ordnance Level	1496·05 Ft.	2627·34 Ft.	2258·28 Ft.	1859·92 Ft.	1537·59 Ft.	966·03 Ft.	1196·48 Ft.		1537·59 Ft.	966·03 Ft.	1196·48 Ft.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January	6·70	5·72	6·85	10·15	12·88	10·17	6·15	8·37	12·86	10·19	6·82
February	8·50	6·47	7·76	10·20	14·30	11·35	7·79	9·48	14·30	11·35	7·33
March	19·93	12·18	14·60	20·93	25·18	18·66	13·43	17·84	25·03	18·66	12·35
April	1·55	1·35	1·05	1·52	2·55	1·83	1·16	1·57	1·90	1·83	1·24
May	3·33	4·50	4·33	4·21	4·48	4·04	3·01	3·99	4·45	4·04	2·77
June	2·42	2·62	3·42	3·31	3·09	2·46	1·46	2·68	3·07	2·46	1·93
July	5·37	6·56	6 83	6·06	6·21	5·41	4·50	5·85	6·18	5·41	3·96
August	8·05	11·01	10·18	10·40	11·30	7·93	6·35	9·32	11·06	7·93	6·40
September	4·55	6·36	5·85	5·10[1]	5·63	4·77	3·50	5·11	5·55	4·77	3·58
October	13·05	14·50	14·72	16·85	16·83	13·96	12·26	14·59	15·80	13·96	11·66
November	4·10	1·53	3·82[2]	4·30	6·54	4·48	3·97	4·11	5·53	4·48	3·57
December	5·40	6·08[2]	5·17[2]	5·20	6·93	5·91	4·41	5·59	6·92	5·91	4·00
Total	82·95	78·88	84·58	98·23	115·92	90·97	67·99	88·50	112·65	90·99	65·61

[1] The gauge at Gameshope Loch was found to have been tampered with, and the average of the remaining gauges for this month has been entered.

[2] The gauge at Ravenscraig was found frozen at the end of November, and the gauge at Loch Craig Head was found frozen at the end of December. They remained frozen for several months, and were emptied on the first opportunity. In dividing the total amount collected during these months the average of the remaining gauges for each month was taken, and the total amounts collected were divided proportionally.

W. A. TAIT.

EDINBURGH AND DISTRICT WATERWORKS (TALLA SCHEME).

Rainfall in 1904.

	Monthly Readings				Daily Readings				Duplicate Gauges—Monthly Readings		
Gauge	No. 1	No. 2	No. 3	No. 4	No. 5a	No. 6a	No. 7a	Average	No. 5	No. 6	No. 7
Position	At Meggat Head (Talla Moss)	At Loch Craig Head	At Ravenscraig	At Gameshope Loch	At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill		At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill
Ordnance Level	1496·05 Ft.	2627·34 Ft.	2258·28 Ft.	1859·92 Ft.	1537·59 Ft.	966·03 Ft.	1196·48 Ft.		1537·59 Ft.	966·03 Ft.	1196·48 Ft.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January . .	7·20	7·46[2]	6·37[2]	6·38	8·84	6·83	5·16	6·89	8·84	6·83	5·00
February .	4·25	4·69[2]	4·00[2]	4·11[2]	4·76	4·50	3·10[3]	4·20	4·76	4·50	3·43[3]
March . .	4·80	4·91[2]	4·16[2]	4·31[2]	5·33	5·08	2·88	4·49	5·34	4·89	3·17
April . . .	6·12	6·73[2]	5·71[2]	6·00	7·72	6·00	5·44	6·24	6·50	5·84	5·02
May . . .	3·50	3·45	4·90	5·44	4·82	4·13	3·33	4·22	3·84	3·95	3·41
June . . .	4·30	4·82	6·43	6·35	6·10	4·68	3·61	5·18	5·84	4·55	3·47
July . . .	4·73	5·63	7·05	6·12	5·91	4·73	3·77	5·42	5·18	4·64	3·43
August . .	6·30	8·03	8·02	7·00[1]	8·53	6·42	4·73	7·00	7·48	6·26	4·70
September .	4·10	5·30	6·64	6·82	6·36	4·20	3·03	5·20	5·17	4·15	3·03
October . .	2·45	3·58	4·68	3·71	3·68	3·16	2·50	3·39	2·79	2·96	2·43
November .	2·50	2·58	2·71	2·45	3·03	2·63	3·03	2·70	2·70	2·55	2·23
December .	5·13	5·76	6·70	5·50	6·37	5·28	4·44	5·60	5·22	5·16	3·72
Total . .	55·38	62·94	67·37	64·19	71·45	57·64	45·02	60·53	63·66	56·28	43·04

[1] The gauge at Gameshope Loch was found to have been tampered with, and the average of the remaining gauges for this month has been entered.

[2] The gauges at Ravenscraig and Loch Craig Head were found frozen at the end of January, and the gauge at Gameshope Loch was found frozen at the end of February. They remained frozen for several months, and were emptied on the first opportunity. In dividing the total amount collected during these months the average of the remaining gauges for each month was taken, and the total amounts collected were divided proportionally.

[3] The gauges at Quarter Hill were covered with snow during this month.

W. A. TAIT.

EDINBURGH AND DISTRICT WATERWORKS (TALLA SCHEME).

Rainfall in 1905.

Gauge	Monthly Readings				Daily Readings			Average	Duplicate Gauges—Monthly Readings		
	No. 1	No. 2	No. 3	No. 4	No. 5a	No. 6a	No. 7a		No. 5	No. 6	No. 7
Position	At Meggat Head (Talla Moss)	At Loch Craig Head	At Ravenscraig	At Gameshope Loch	At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill		At Gameshope Farm	At Talla Linns Foot Farm	At Quarter Hill
Ordnance Level	1496·05 Ft.	2627·34 Ft.	2258·28 Ft.	1859·92 Ft.	1537·59 Ft.	966·03 Ft.	1196·48 Ft.		1537·59 Ft.	966·03 Ft.	1196·48 Ft.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January . .	2·20	2·21[1]	2·19	1·89	3·03	2·73	2·58	2·40	2·50	2·66	2·53
February .	3·05	2·45[1]	2·01[2]	1·85	2·71	3·43	2·50	2·57	2·43	3·30	2·29
March . .	9·03	7·78[1]	6·39[2]	8·08	10·14	9·19	6·62	8·18	8·20	9·00	6·56
April . . .	4·35	4·50	5·71	5·43	5·58	4·48	3·39	4·78	5·05	4·33	3·29
May . . .	2·95	3·73	5·80	4·96	4·82	3·17	2·56	3·99	3·96	3·05	2·32
June . . .	2·10	2·53	1·42	3·52	3·39	2·54	2·33	2·54	3·02	2·51	2·34
July . . .	3·37	3·48	5·96	4·38	4·44	3·71	3·18	4·07	4·18	3·58	3·16
August . .	5·50	7·78	7·50	7·66	8·37	6·39	4·41	6·80	7·23	6·19	4·25
September .	2·70	3·96	4·10	4·12	3·92	3·13	2·76	3·53	3·73	2·99	2·67
October . .	4·17	4·42	4·35[2]	4·45	5·12	4·27	3·68	4·35	4·68	4·12	3·73
November .	6·50	6·38[1]	5·98	7·75	8·89	8·11	5·67	7·04	8·50	7·91	5·50
December .	2·67	4·04	5·69	5·07	5·70	4·41	3·97	4·51	5·11	4·28	3·87
Total . .	48·59	53·26	57·10	59·16	66·11	55·56	43·65	54·76	58·59	53·92	42·51

[1] The gauge at Loch Craig Head was found frozen at the end of January, and the gauge at Ravenscraig was found frozen at the end of February. These gauges were not emptied until the end of March, and the total amounts collected in them during the months they were frozen were divided proportionally, in accordance with the average of the remaining gauges in each month.

[2] The gauge at Ravenscraig appeared to have been tampered with, and the average of the remaining gauges for this month has been entered.

W. A. TAIT.

APPENDIX II.

AVERAGE MONTHLY GAUGINGS OF BLACK SPRINGS.

(Cubic Feet per Minute.)

	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882
January	49·5	98·1	34·2	69·0	82·6	83·6	60·6	52·3	68·0	45·9	88·8	101·5	66·7	110·7	54·5	75·2	53·7	54·2	44·5	61·8	61·2
February	60·6	80·5	61·1	36·6	80·5	78·6	85·4	77·8	37·5	66·7	68·9	43·9	35·4	55·6	53·2	99·8	55·8	42·7	38·2	51·5	40·5
March	54·2	31·7	82·2	52·4	72·0	38·8	58·5	50·6	65·7	47·9	45·7	46·1	22·5	45·7	76·5	41·7	39·7	64·0	56·6	62·2	78·5
April	48·1	29·4	34·6	27·6	69·9	47·3	50·1	29·3	29·9	51·1	71·9	32·8	42·2	27·6	54·9	54·9	26·2	65·2	46·5	30·2	48·8
May	41·1	28·2	25·4	35·6	39·7	44·2	44·2	30·0	23·1	47·3	71·0	23·7	21·1	21·3	45·7	49·7	26·6	38·7	39·5	26·6	62·6
June	36·8	34·5	18·6	31·3	26·4	41·7	24·3	25·3	16·5	23·6	46·6	21·7	13·2	16·3	25·7	33·4	33·2	42·5	24·2	24·3	28·0
July	29·7	27·4	14·8	21·1	19·4	53·2	17·9	20·6	14·4	19·1	31·3	17·1	10·2	14·8	21·1	50·9	23·5	132·2	17·5	19·8	25·8
August	52·6	19·3	12·3	16·0	26·8	33·2	14·8	16·3	12·5	19·7	32·9	16·5	32·5	13·6	16·7	94·3	17·1	55·6	15·2	41·2	22·0
September	29·8	25·7	10·9	14·2	24·9	30·3	16·5	14·1	11·1	21·3	82·5	32·1	24·3	16·2	26·3	79·6	37·3	38·6	19·8	62·2	21·5
October	46·9	36·4	47·8	75·7	27·8	24·5	28·6	23·1	11·2	32·9	58·0	77·5	56·0	43·2	58·2	35·6	49·6	30·3	34·8	48·2	34·2
November	51·3	52·6	71·4	55·1	51·8	26·0	57·8	24·7	15·1	53·1	115·4	86·9	42·5	68·6	59·1	69·3	52·4	35·8	55·4	45·2	52·5
December	51·2	59·0	64·6	55·9	64·1	22·8	65·2	38·1	26·5	65·2	79·9	38·1	77·7	76·1	80·9	57·7	65·5	38·2	61·5	60·0	73·0

	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905
January	97	54	46	43	55	36	31	63	28	47	32	47	33	40	48	53	88	83	42	63	92	57	
February	60	80	70	67	49	43	31	50	27	47	45	149	24	29	40	30	59	77	34	32	111	64	
March	30	43	38	76	36	60	37	36	40	58	57	86	68	39	60	26	32	74	42	29	104	44	
April	26	28	57	59	32	80	53	30	43	34	26	30	63	27	48	41	52	49	43	27	58	43	
May	20	28	40	45	24	38	38	22	25	25	19	26	30	19	29	32	67	30	24	31	34	58	
June	16	22	29	43	22	26	25	30	18	29	25	47	20	19	34	24	33	25	17	40	26	34	
July	21	42	20	24	18	31	23	31	15	26	24	25	18	25	26	19	34	22	13	25	20	25	
August	26	27	17	18	14	36	65	38	32	20	24	29	29	23	18	14	21	37	12	19	28	31	
September	25	21	14	14	18	25	37	33	109	39	19	23	26	37	17	13	20	33	13	16	28	27	
October	36	19	25	59	25	20	46	28	68	60	23	19	28	83	15	41	21	64	15	15	71	21	
November	53	34	26	54	70	54	43	99	49	43	37	43	51	38	20	85	54	92	51	18	48	19	
December	54	66	33	44	60	71	31	59	97	50	45	33	57	72	47	71	38	98	47	26	60	51	

Average Monthly Gaugings of Bavelaw and Listonshiels Springs.

(Cubic Feet per Minute.)

	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881
January . .	148·5	145·1	145·2	148·4	159·7	160·6	161·1	184·7	197·5	..	..	202·1	..	..	..	216·5	194·2	182·6	184·8	181·5
February .	153·1	149·6	150·7	143·2	167·2	163·7	192·4	199·8	201·1	..	..	218·0	..	..	208·9	227·3	213·9	180·4	186·8	182·7
March . .	145·6	145·9	148·5	143·2	160·7	154·6	190·4	166·2	200·6	..	..	222·4	..	..	231·6	184·6	207·9	183·1	188·2	185·6
April . .	150·1	144·4	146·3	137·2	163·9	161·3	185·5	175·2	189·8	..	..	212·7	..	..	204·3	223·8	198·1	187·8	187·0	177·8
May . . .	147·1	145·9	141·6	136·8	165·3	154·5	179·9	197·8	185·8	..	..	307·5	..	..	194·3	205·5	204·3	185·8	187·0	174·0
June . .	146·3	148·6	138·4	145·5	151·1	169·2	177·4	197·0	180·5	..	..	193·4	..	..	..	205·8	194·4	185·0	178·8	170·2
July . .	141·2	141·0	135·4	151·0	144·6	165·7	168·0	191·4	..	..	..	..	..	..	..	210·2	188·7	193·9	174·5	170·8
August . .	148·0	139·3	132·6	151·7	149·7	153·0	181·8	182·6	..	..	..	..	..	..	..	206·2	180·2	174·7	170·3	169·1
September .	139·9	148·6	131·6	149·8	142·1	152·2	176·2	183·0	..	..	..	..	..	..	..	200·5	182·5	180·2	178·8	175·8
October .	145·2	146·0	133·3	163·6	148·6	150·9	179·7	179·8	..	..	247·9	..	..	..	..	192·9	203·2	186·5	172·5	175·2
November .	142·4	144·6	139·5	152·8	154·3	150·5	186·9	186·5	..	..	252·1	..	..	..	174·6	220·7	180·6	185·5	177·0	176·4
December .	144·8	149·6	142·7	159·5	158·0	174·5	201·7	191·7	..	..	250·4	..	..	..	181·3	215·4	186·4	205·8	181·2	155·0

	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904
January . .	183·2	169·2	154·0	157	148	155	150	162	164	159	165	152	145	144	144	146	145	152	154	169	157	148	154
February .	183·2	170·2	159·0	161	158	152	150	172	162	156	164	155	158	141	144	146	146	154	156	169	150	156	156
March . .	199·9	158·0	158·0	157	154	150	153	172	161	158	164	160	168	147	145	151	145	151	163	170	149	162	156
April . .	188·8	154·0	154·0	155	157	149	160	173	157	157	157	151	159	149	141	150	147	154	161	169	149	163	157
May . . .	188·8	150·7	156·0	156	152	144	155	170	155	153	153	145	155	145	138	147	145	154	155	163	144	158	157
June . .	182·2	149·0	155·0	151	153	143	151	162	154	147	154	142	158	138	135	145	142	151	154	156	145	152	154
July . .	181·0	148·5	156·0	146	147	141	153	156	152	142	151	143	150	135	133	144	138	150	152	151	143	149	151
August . .	178·0	144·7	151·4	143	143	138	153	166	153	147	147	140	150	135	132	142	133	144	152	150	141	148	149
September .	179·5	142·0	149·0	145	142	139	149	157	151	153	150	137	145	134	134	140	133	142	148	146	138	144	144
October .	184·2	144·0	149·0	146	148	139	146	163	148	156	154	138	139	137	142	136	137	142	151	145	137	151	140
November .	187·5	149·7	150·0	144	150	152	151	159	160	156	155	141	146	143	143	137	142	144	156	151	136	151	141
December .	192·0	151·0	157·0	143	152	152	153	159	163	165	153	142	145	148	149	140	149	146	170	155	138	154	142

AVERAGE MONTHLY GAUGINGS OF COLZIUM SPRINGS.

(Cubic Feet per Minute.)

	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881
January .	246·9	255·3	237·6	245·5	245·2	246·3	215·0	224·0	224·0	..	..	224·0	..	..	220·0	224·0	224·0	221·0	221·0	221·0
February .	254·2	261·0	244·9	227·6	246·5	255·3	224·0	224·0	224·0	..	..	224·0	..	..	221·6	224·0	224·0	217·0	223·0	222·0
March . .	246·1	248·7	244·9	231·7	242·5	250·1	223·0	224·0	224·0	..	..	224·0	..	..	220·0	224·0	224·0	221·0	224·0	223·2
April . .	246·9	244·0	239·1	217·2	246·2	251·3	222·4	224·0	220·5	..	..	224·0	..	..	218·0	224·0	224·0	224·0	224·0	221·0
May . . .	246·3	245·2	226·4	215·5	230·9	244·9	222·0	221·0	214·0	..	..	224·0	..	..	222·4	224·0	224·0	220·0	224·0	219·2
June . .	242·4	245·1	219·7	202·7	217·2	248·9	211·7	216·8	208·8	..	..	222·0	..	..	220·0	223·0	220·0	221·0	221·6	212·0
July . . .	237·2	227·3	210·6	209·7	210·5	242·8	194·8	190·2	..	..	..	..	..	..	206·0	224·0	212·1	224·0	215·5	215·0
August . .	250·2	221·2	203·3	207·1	216·6	235·3	191·5	202·2	..	..	..	..	..	..	200·2	224·0	205·0	224·0	199·1	209·1
September .	236·4	235·0	207·1	200·9	213·3	231·0	196·8	205·0	..	..	..	..	..	..	219·5	224·0	218·0	224·0	205·8	212·5
October . .	243·6	242·4	207·5	235·9	215·1	227·3	204·7	215·0	..	..	224·0	..	..	..	222·4	224·0	203·1	224·0	206·0	214·0
November .	244·9	242·4	245·6	219·4	234·7	225·4	221·0	218·5	..	..	224·0	..	..	..	221·5	224·0	220·0	224·0	216·0	216·4
December .	252·2	250·1	240·3	211·5	250·2	228·6	222·0	221·1	..	..	224·0	..	..	..	224·0	224·0	220·8	221·6	220·0	220·0

AVERAGE MONTHLY GAUGINGS OF COLZIUM SPRINGS. (Cubic Feet per Minute.) — 1882–1895

OWING TO NEW RETURNS AVERAGE MONTHLY GAUGINGS OF CROSSWOOD AND COLZIUM AND NORTH LISTONSHIELS SPRINGS. — 1896–1904

	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904
January .	224·0	224	223	220	204	210	206	217	222	224	224	220	209	..	..	308	309	347	342	355	345	322	345
February .	223·0	224	224	224	219	215	205	222	220	221	224	220	227	..	..	312	305	344	353	349	326	352	339
March . .	224·0	224	224	220	211	210	209	220	220	222	224	222	226	..	..	314	307	326	349	349	328	360	342
April . .	224·0	222	223	219	220	210	215	221	220	222	220	217	210	..	..	328	317	328	342	349	331	355	349
May . . .	224·0	220	222	218	210	204	210	214	207	216	220	210	215	..	..	309	317	335	331	336	319	345	348
June . .	223·0	218	215	213	210	197	203	201	208	212	220	202	214	..	..	299	302	313	324	324	324	311	331
July . . .	223·0	216	214	200	198	182	205	193	215	199	215	196	..	..	..	287	288	309	324	310	301	312	319
August . .	220·8	216	214	188	190	178	203	210	214	211	214	192	..	..	..	284	279	281	324	299	300	315	307
September .	220·0	214	214	193	192	190	203	200	214	219	214	187	..	..	..	276	275	288	300	282	290	312	303
October . .	219·6	221	206	201	204	186	195	218	214	222	220	185	..	..	..	270	318	302	328	303	279	337	288
November .	223·0	221	208	198	207	208	202	214	224	220	222	190	..	..	..	290	319	324	342	339	279	337	292
December .	224·0	222	219	197	213	211	222	216	224	224	221	200	..	..	313	315	345	315	366	348	301	339	313

The independent gauging of Colzium Springs and Crosswood Springs had to be stopped owing to alterations at Thrashiedean Cistern during 1904.

AVERAGE MONTHLY GAUGINGS OF CROSSWOOD SPRINGS.

(Cubic Feet per Minute.)

	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877
January	..	..	..	..	..	..	88·0	135·0	160·2	..	..	107·0	..	..	..	122·8
February	..	..	..	..	..	..	99·7	154·7	141·7	..	..	84·0	..	..	113·6	106·3
March	..	..	..	..	..	..	93·2	117·7	152·7	..	..	92·5	..	..	110·7	93·3
April	..	..	..	..	..	..	88·8	135·5	126·5	..	..	94·0	..	..	93·2	108·3
May	..	..	..	..	..	..	88·5	126·0	113·7	..	..	74·2	..	..	101·7	121·6
June	..	..	..	..	..	..	74·2	109·1	116·4	..	..	108·0	..	..	90·5	90·3
July	..	..	..	..	..	..	67·1	89·2	..	..	..	..	..	..	92·8	92·1
August	..	..	..	..	..	..	65·5	99·2	..	..	..	..	..	..	81·6	103·8
September	..	..	..	..	..	..	100·4	101·2	..	..	..	..	..	..	86·5	84·0
October	..	..	..	..	..	..	118·5	104·0	..	..	..	..	..	..	78·6	100·1
November	..	..	..	..	..	..	133·5	137·0	..	..	107·5	..	..	..	81·0	118·0
December	..	..	..	..	..	..	122·0	143·7	..	..	90·7	..	..	..	83·3	108·0

	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894
January	154·0	120·2	82·5	86·0	90·0	107·4	123·2	107	114	99	90	106	101	108	97	77	86
February	128·2	107·2	88·2	87·0	86·0	102·2	115·0	112	121	99	101	103	104	108	95	77	105
March	137·2	119·2	87·4	90·6	81·5	85·0	109·0	109	108	96	84	109	109	85	80	80	108
April	128·6	133·4	84·0	80·5	91·5	104·5	117·0	112	101	107	77	100	107	121	77	67	100
May	121·8	109·5	80·0	75·4	106·8	107·0	109·0	110	103	95	99	112	92	112	72	58	97
June	128·0	85·0	75·0	66·2	91·2	112·4	104·0	103	105	92	91	102	94	95	73	59	101
July	110·1	105·1	74·0	69·8	80·2	89·2	101·0	97	100	90	86	110	99	84	75	64	
August	110·2	95·0	83·4	69·8	81·2	102·0	102·4	93	91	97	90	92	94	90	66	61	
September	115·0	92·0	83·5	74·7	77·0	92·0	99·0	109	95	104	96	112	91	110	72	60	
October	97·4	83·5	75·2	73·2	85·6	88·2	110·2	119	92	95	100	88	85	79	75	70	
November	98·0	88·5	89·4	77·4	82·2	82·2	112·2	112	108	95	87	98	98	77	78	80	
December	118·4	88·8	84·7	85·0	97·5	92·5	98·2	110	100	97	94	100	111	105	79	82	

The independent gauging of Colzium Springs and Crosswood Springs had to be stopped owing to alterations at Thrashiedean Cistern during 1904.

MONTHLY REGISTER OF RAINFALL AND EVAPORATION AT GLENCORSE,

700 Feet above Ordnance datum.

	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January	3·30	7·00	2·30	4·75	4·40	6·05	5·85	3·50	2·40	2·75	5·50	4·95	3·45	5·70	2·60
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
February	2·00	2·65	3·10	1·75	4·60	2·95	6·00	4·80	4·05	2·95	2·55	1·40	1·20	2·05	4·00
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
March	4·70	0·95	4·05	1·40	1·85	1·85	3·85	1·55	2·10	1·80	4·60	1·50	2·25	1·55	6·10
	..	*0·50*	..	..	..	..	*0·20*	*0·30*	..	*0·35*	*0·35*	..	*0·35*	*0·35*	..
April	2·55	3·40	0·90	0·40	2·20	3·85	4·55	2·00	0·70	4·55	3·35	0·40	2·75	1·15	2·95
	1·05	*1·25*	*1·10*	*1·20*	*0·55*	*0·15*	*1·00*	*1·90*	*1·80*	*0·20*	*1·10*	*1·35*	*1·55*	*1·35*	*0·30*
May	3·40	2·10	1·90	6·00	2·00	2·80	2·50	2·85	1·60	0·70	5·20	2·50	2·00	1·60	1·60
	1·90	*2·05*	*2·45*	*1·10*	*2·40*	*1·15*	*2·55*	*2·00*	*1·65*	*2·40*	*1·65*	*0·90*	*1·70*	*2·25*	*2·45*
June	3·20	3·85	1·40	0·40	1·25	2·50	1·15	3·10	3·20	2·35	3·30	0·65	1·50	2·75	3·40
	1·90	*1·95*	*1·90*	*2·60*	*1·25*	*2·50*	*2·90*	*2·35*	*2·05*	*2·15*	*2·10*	*1·70*	*2·80*	*2·05*	*2·80*
July	3·80	0·65	2·35	3·40	4·75	7·65	0·55	0·95	1·95	3·15	3·75	3·85	2·40	3·85	2·35
	2·10	*2·85*	*2·35*	*1·30*	*2·55*	*2·00*	*3·00*	*3·00*	*2·45*	*1·60*	*2·15*	*2·10*	*1·20*	*2·45*	*2·95*
August	6·00	4·15	0·40	4·50	3·70	2·10	5·80	1·25	1·75	2·65	3·70	4·45	6·60	2·50	4·35
	1·90	*2·15*	*2·70*	*1·40*	*0·60*	*1·90*	*2·50*	*2·40*	*2·40*	*2·00*	*1·00*	*2·00*	*2·00*	*1·80*	*2·30*
September	2·05	4·75	3·55	0·70	3·65	2·40	4·55	5·65	2·50	3·10	6·15	3·40	3·20	4·50	4·50
	1·10	*0·95*	*0·65*	*1·80*	*1·25*	*1·40*	*1·45*	*0·85*	*1·40*	*1·15*	*0·60*	*1·60*	*1·25*	*1·05*	*1·20*
October	6·25	3·10	9·90	6·65	1·45	2·40	2·90	2·25	3·50	2·55	5·45	6·10	5·15	3·50	3·55
	0·30	*0·75*	*0·60*	..	*0·50*	*0·65*	*1·00*	*1·05*	*0·15*	*0·45*	*0·30*	*0·45*	*0·75*	*0·65*	*0·30*
November	2·05	2·65	3·25	2·95	2·50	0·25	3·05	2·70	1·55	4·70	5·75	4·20	4·70	5·75	4·20
	..	..	*0·40*	*0·10*	..	*0·70*	*0·10*	*0·30*	..	..	..	*0·10*	..	..	..
December	3·50	3·65	2·65	2·70	5·15	2·60	5·25	3·55	2·40	3·20	2·90	2·90	2·55	3·00	5·75
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	42·80	38·90	35·75	35·60	37·50	37·40	46·00	34·15	27·70	34·45	52·20	36·30	37·75	37·90	45·35
	10·25	*12·45*	*12·15*	*9·50*	*9·10*	*10·45*	*14·70*	*14·15*	*11·90*	*10·30*	*9·25*	*10·20*	*11·60*	*11·95*	*12·30*

NOTE.—The evaporation is given in italic figures.

MONTHLY REGISTER OF RAINFALL AND EVAPORATION AT GLENCORSE—*continued.*

700 Feet above Ordnance datum.

	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January	9·40	4·45	1·70	1·80	2·75	3·60	5·75	6·00	2·50	8·00	2·05	2·15	1·85	6·20	2·00
	..	..	..	..	..	..	..	..	..	..	..	..	*0·25*	..	*0·30*
February	3·30	1·40	3·70	3·10	3·55	2·50	2·20	2·25	3·90	2·10	2·40	3·65	3·40	1·00	0·35
	..	..	..	*0·10*	..	..	..	*0·05*	..	..	..	..	..	*0·50*	*0·25*
March	2·45	1·30	4·00	2·70	4·50	5·25	2·85	2·45	2·15	3·85	2·70	7·10	2·30	2·75	..
	..	*0·80*	*1·10*	*0·70*	..	*0·60*	..	*0·35*	*0·35*	..	..	..	*0·25*	*0·50*	..
April	4·00	1·85	3·30	5·00	0·80	3·75	1·60	1·35	3·00	2·75	1·55	2·75	3·60	1·30	0·70
	1·10	*0·95*	*1·20*	*1·40*	*1·35*	*1·00*	*1·20*	*0·95*	*1·25*	*0·95*	*1·10*	*0·70*	*0·50*	*1·60*	*1·50*
May	3·20	3·90	2·30	2·50	3·40	2·40	1·70	3·25	3·65	5·80	3·35	1·65	2·30	2·60	..
	2·00	*2·10*	*1·70*	*2·20*	*2·40*	*2·30*	*2·35*	*2·25*	*1·35*	*2·00*	*2·10*	*2·45*	*1·50*	*2·30*	..
June	3·40	2·35	6·20	2·50	2·85	4·83	2·40	0·60	0·70	1·65	0·50	3·30	1·30	4·10	0·80
	2·50	*2·25*	*1·55*	*2·00*	*2·00*	*1·40*	*2·15*	*2·20*	*2·30*	*2·55*	*2·85*	*1·90*	*3·70*	*1·85*	*1·60*
July	6·20	0·50	11·00	3·95	4·10	3·75	4·25	5·50	0·95	3·25	3·35	7·10	5·50	4·50	3·07
	2·20	*2·95*	*1·80*	*2·00*	*2·65*	*2·00*	*2·25*	*0·50*	*2·25*	*2·80*	*3·55*	*2·00*	*3·00*	*3·60*	*2·57*
August	9·60	6·90	4·00	1·10	7·10	2·20	3·15	1·60	3·05	1·60	2·50	2·40	6·30	5·00	5·90
	1·35	*2·15*	*1·70*	*1·90*	*1·70*	*2·00*	*1·90*	*1·90*	*2·10*	*1·80*	*2·60*	*2·60*	*2·25*	*2·10*	*1·50*
September	2·05	4·40	2·15	4·10	4·25	2·95	3·50	3·55	4·40	4·45	5·50	1·30	1·30	2·45	6·33
	1·40	*1·80*	*1·35*	*1·60*	*0·65*	*1·50*	*1·30*	*1·30*	*1·00*	*1·30*	*1·50*	*2·00*	*1·90*	*2·00*	*1·13*
October	3·75	3·75	1·85	4·55	2·70	3·25	3·60	2·15	2·90	5·75	3·20	2·60	4·45	3·20	2·90
	0·50	*0·80*	*0·85*	*0·20*	*0·50*	*0·30*	*0·80*	*0·70*	*0·45*	*0·05*	*1·20*	*0·60*	*0·70*	*1·40*	*2·00*
November	3·95	3·80	3·85	6·25	3·85	4·40	4·05	2·65	1·95	3·65	5·05	7·70	0·85	7·70	1·95
	..	*0·15*	*0·40*	..	..	*0·15*	*0·15*	..	..	*0·05*	*0·50*	..	*0·35*	*0·40*	..
December	3·00	3·80	2·70	7·45	2·50	8·45	2·25	4·80	3·25	4·05	2·05	2·00	2·85	3·30	5·62
	..	..	..	..	..	..	..	..	..	*0·05*	*0·15*	*0·10*	*0·75*	..	*0·22*
Total	54·30	38·40	46·75	45·00	42·35	47·33	37·30	36·15	32·40	46·90	34·20	43·70	36·00	44·10	..
	11·05	*13·95*	*11·65*	*12·10*	*11·25*	*11·25*	*12·10*	*10·20*	*11·05*	*12·00*	*15·55*	*12·35*	*14·80*	*14·15*	..

NOTE.—The evaporation is given in italic figures.

MONTHLY REGISTER OF RAINFALL AND EVAPORATION AT GLENCORSE—*continued.*

700 Feet above Ordnance datum.

	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January	1·33	1·50	3·80	2·40	1·50	1·60	1·50	5·40	4·65	2·25	1·49	5·90	3·74
	..	..	*0·20*	*0·70*	*0·50*	*0·85*	*0·35*	..	*0·15*	*0·10*	*0·04*	*0·00*	..
February	3·75	4·00	8·90	1·05	1·00	2·35	2·45	2·05	5·05	1·45	1·04	6·47	3·76
	..	*0·30*	*0·20*	*0·75*	*0·40*	*0·75*	*0·30*	*0·25*	*0·00*	*0·10*	*0·09*	*0·17*	..
March	2·00	1·40	2·85	6·90	3·15	4·05	2·30	3·15	1·85	3·35	2·27	6·57	1·75
	..	*0·95*	..	*2·40*	*1·15*	*1·15*	*0·65*	*0·85*	*0·40*	*0·65*	*0·62*	*0·47*	*0·35*
April	1·80	1·70	1·55	2·30	1·90	2·00	2·45	4·15	2·45	2·34	1·58	1·41	3·48
	1·70	*1·90*	*1·95*	*1·70*	*2·50*	*3·00*	*1·25*	*1·45*	*1·70*	*1·44*	*1·28*	*1·11*	*1·43*
May	3·70	2·30	4·55	1·20	0·85	2·15	2·15	4·50	2·00	3·02	3·40	2·86	4·69
	2·40	*2·60*	*3·15*	*3·60*	*4·05*	*2·45*	*2·15*	*2·10*	*2·15*	*2·02*	*2·10*	*1·66*	*1·94*
June	3·65	4·70	3·05	2·25	4·50	5·00	2·55	1·55	3·55	2·31	3·68	2·00	3·18
	2·35	*2·90*	*5·65*	*4·25*	*5·00*	*2·70*	*2·25*	*2·85*	*2·25*	*3·01*	*1·53*	*2·40*	*2·28*
July	1·55	3·70	1·75	5·25	5·00	3·40	1·40	4·50	3·05	0·95	2·55	4·87	2·32
	2·35	*2·20*	*3·85*	*3·85*	*5·20*	*3·80*	*2·90*	*2·55*	*2·55*	*2·85*	*2·35*	*2·72*	*2·02*
August	5·00	3·85	4·90	5·60	1·45	3·70	4·05	0·75	4·85	5·37	1·67	3·77	5·80
	2·30	*2·45*	*3·90*	*3·40*	*3·15*	*2·10*	*2·25*	*2·40*	*1·95*	*3·02*	*1·87*	*2·37*	*2·20*
September	2·20	2·05	0·70	0·95	5·80	2·65	2·65	3·05	3·85	1·52	2·22	2·74	1·67
	1·10	*3·25*	*1·80*	*3·65*	*2·80*	*1·80*	*1·45*	*1·95*	*1·60*	*1·92*	*1·07*	*1·24*	*1·57*
October	4·80	3·00	2·75	4·15	6·55	1·45	4·35	4·40	4·80	2·60	2·59	8·11	1·54
	0·90	*2·10*	*0·95*	*2·25*	*1·75*	*1·00*	*0·90*	*1·10*	*1·20*	*1·35*	*0·69*	*0·96*	*0·89*
November	2·30	2·15	2·40	4·10	1·55	3·10	5·95	4·15	6·25	3·98	1·04	2·62	1·78
	0·60	*0·55*	*0·50*	*0·80*	*0·55*	*0·60*	*0·55*	*0·45*	*0·60*	*0·23*	*0·19*	*0·27*	*0·33*
December	2·95	3·45	2·90	3·65	4·90	4·85	5·00	2·80	7·15	3·96	3·70	2·14	3·87
	0·75	*0·55*	*0·20*	*0·55*	*0·80*	..	*0·65*	*0·10*	*0·55*	*0·11*	*0·15*	..	..
Total	35·03	33·80	40·10	39·80	38·15	36·30	36·80	40·45	49·50	33·10	27·23	49·46	37·58
	14·45	*19·75*	*22·35*	*27·90*	*27·85*	*20·20*	*15·65*	*16·05*	*15·10*	*16·80*	*11·98*	*13·37*	*13·01*

NOTE.—The evaporation is given in italic figures

MONTHLY REGISTER OF RAINFALL AT MOORFOOT,

900 Feet above Ordnance datum.

	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885
January	..	6·22	3·92	3·17	..	..	..	3·26	6·78	1·43	8·87	4·60	1·45	1·45	1·41	2·60	3·73	7·12	3·13
February	..	4·55	4·54	4·60	..	..	..	2·50	0·93	5·13	3·36	1·55	3·68	3·77	2·47	2·10	3·49	3·50	3·47
March	..	5·18	1·38	1·30	..	..	..	2·82	1·43	..	3·33	1·30	3·42	1·53	2·11	4·10	3·40	2·37	1·68
April	..	5·00	2·13	1·30	..	..	..	2·38	1·37	4·70	4·98	1·90	2·40	5·42	0·40	3·24	1·64	1·94	3·06
May	..	2·71	2·75	2·52	..	..	..	1·56	2·00	1·55	4·00	3·10	2·30	1·78	3·02	1·71	1·13	3·49	3·58
June	..	1·33	2·72	3·00	..	..	..	1·29	3·33	..	3·08	3·00	5·37	2·12	1·60	3·39	2·35	1·20	0·75
July	..	1·00	1·27	1·44	..	..	..	3·00	3·52	..	5·79	1·38	6·80	3·21	3·70	4·80	4·02	4·60	1·40
August	..	5·59	0·81	1·83	..	..	..	6·10	2·32	5·85	7·70	6·55	4·35	0·81	5·80	2·18	3·30	2·11	2·52
September	2·63	4·64	5·35	2·50	..	..	..	2·75	3·64	5·15	2·60	3·93	2·32	6·01	3·95	2·53	3·22	2·75	3·95
October	2·35	4·19	2·38	4·44	..	..	..	4·45	6·04	2·62	4·64	3·13	1·60	4·14	3·25	2·80	4·37	2·18	4·10
November	1·01	3·23	4·31	2·20	..	..	..	6·82	5·80	5·14	5·35	4·05	3·13	5·07	2·56	4·20	3·22	1·90	2·10
December	2·33	5·61	2·94	3·28	..	..	..	3·67	3·46	8·45	2·85	4·05	1·68	3·77	3·07	3·30	2·63	4·41	1·93
	8·32	49·25	34·50	31·58	..	..	..	40·60	40·62	..	56·55	38·54	38·50	39·08	33·34	36·95	36·50	37·57	31·67

New gauge from 1901.

	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904
January	5·73	2·24	1·85	1·34	4·36	1·25	1·60	0·94	3·23	2·35	1·35	1·76	1·50	4·90	3·80	2·42	1·30	5·25	2·60
February	2·22	1·70	3·20	2·28	1·12	0·62	2·28	3·0	7·3	1·25	1·10	2·20	2·35	1·75	4·42	1·46	1·04	5·53	3·20
March	3·94	2·39	4·45	2·17	3·60	3·42	1·55	0·9	2·5	4·65	2·88	4·45	1·70	2·20	1·53	2·22	1·92	4·30	1·68
April	2·23	1·35	2·03	3·01	1·22	1·50	1·50	0·6	1·54	1·75	1·56	1·45	2·40	4·00	2·19	1·85	1·75	1·42	2·15
May	4·92	2·32	1·35	1·61	1·82	1·77	3·02	1·7	4·1	1·70	0·80	1·80	2·03	3·08	1·80	2·34	3·04	2·33	3·23
June	1·50	0·60	2·60	1·25	3·97	0·41	3·55	4·9	2·3	1·62	2·62	3·37	2·40	1·12	3·77	2·31	3·62	1·80	2·77
July	3·05	2·32	5·40	4·45	3·36	3·67	2·1	2·28	1·24	5·15	4·00	2·30	1·45	3·75	3·02	1·13	2·48	4·18	1·67
August	1·53	2·85	2·00	5·97	5·20	6·47	4·1	3·0	4·4	5·02	1·30	4·66	3·54	0·75	3·89	5·33	1·43	4·30	4·80
September	3·70	4·60	1·00	1·23	1·67	7·78	2·5	1·54	1·10	0·52	4·45	2·85	2·45	3·40	2·90	1·26	2·17	2·23	1·75
October	6·17	2·25	1·45	5·54	2·95	3·00	5·15	2·3	2·58	4·40	5·52	1·30	4·00	3·38	4·25	2·99	2·09	8·23	1·20
November	3·25	5·30	7·65	1·05	6·65	3·00	1·4	2·62	2·52	3·75	1·85	2·72	5·30	4·60	4·40	3·55	2·22	2·46	2·08
December	5·32	2·54	1·73	2·19	3·02	6·65	1·7	3·0	2·00	4·36	4·50	4·45	3·95	2·50	5·21	6·11	3·62	2·23	3·00
	43·56	30·46	34·71	32·09	38·94	39·54	30·45	26·78	34·81	36·52	31·93	33·31	33·07	34·43	41·18	32·97	26·68	44·26	30·13

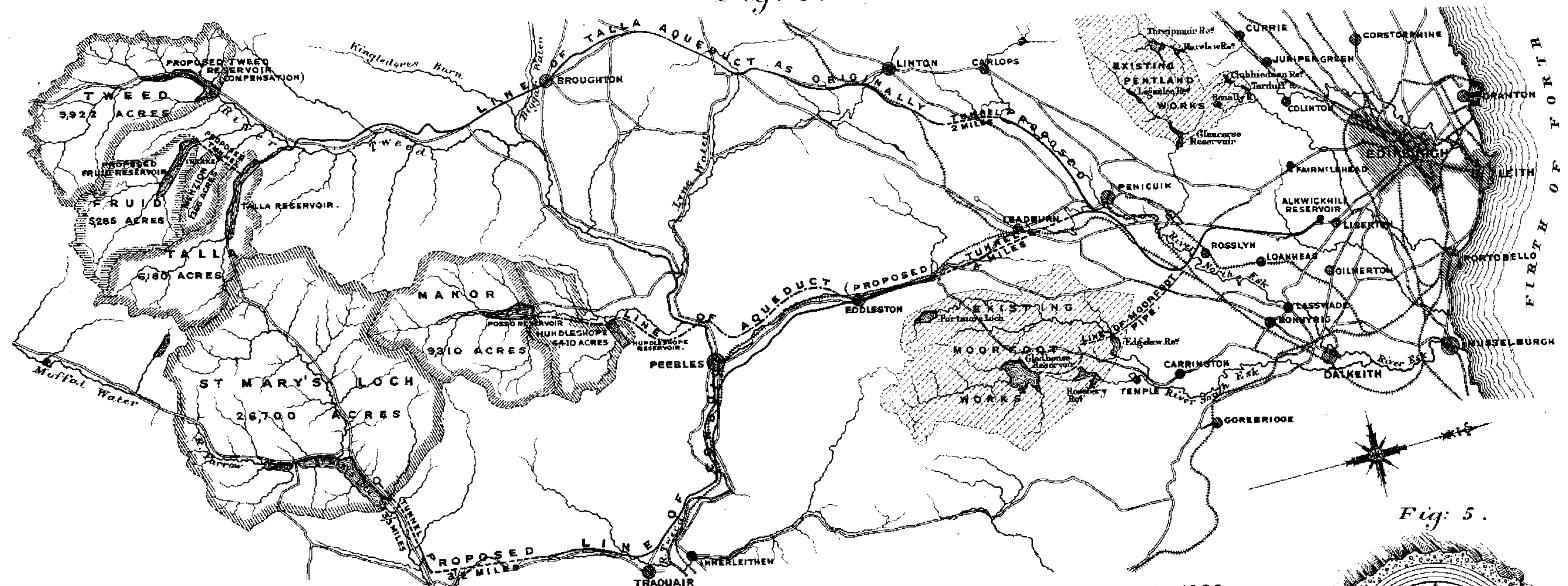
APPENDIX III.

SECTION 23 OF THE EDINBURGH AND DISTRICT WATER WORKS ACT, 1898.

Laying Mains on Public Roads.—The trustees may at any time for the purposes of conveying water from any of the sources of their water supply whether existing or authorized or for distributing and supplying water within the limits districts or areas or any part of the same within which the trustees are authorized to supply sell or distribute water either in bulk or otherwise and that whether within the limits of the Act or beyond the same and so far as beyond such limits with the consent of the road authority lay down make and maintain and use aqueducts conduits or lines of pipe through over under along across or into any public road or highway and renew alter enlarge duplicate and increase the number and size thereof or extend the same and stop up temporarily any such public road or highway for such purposes providing when possible a proper temporary substitute to the reasonable satisfaction of the road authority before interrupting the traffic on any such road and making full compensation to all persons injuriously affected by anything done under the provisions of this section.

TALLA WATER-SUPPLY OF EDINBURGH AND DISTRICT.

Fig: 1.



PLAN SHOWING ORIGINAL EDINBURGH WATERWORKS, TALLA, AND OTHER PROPOSED SCHEMES, 1889.

SCALES.

Fig: 1 — 1 Inch = 4 Miles.

Fig: 2 (Vertical) & Fig: 4 — 1 Inch = 80 Feet.

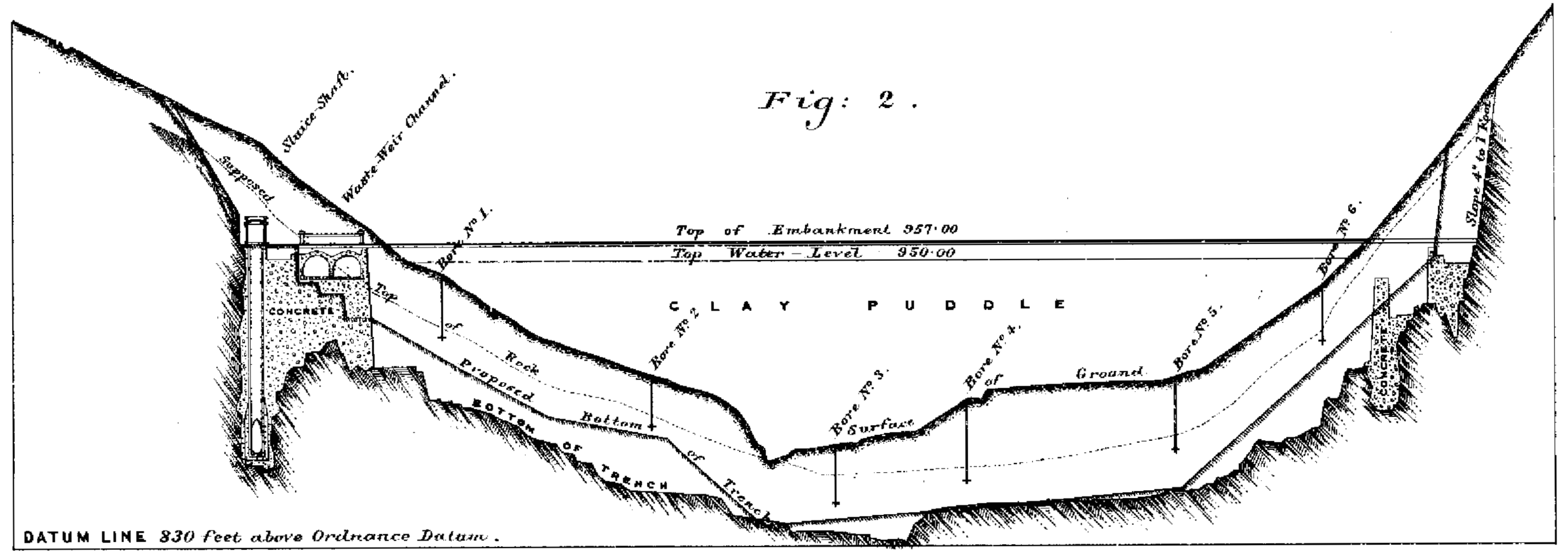
Fig: 6 — 1 Inch = 20 Feet.

Fig: 2 (Horizontal) — 1 Inch = 200 Feet.

Fig: 5 — 1 Inch = 12 Feet.

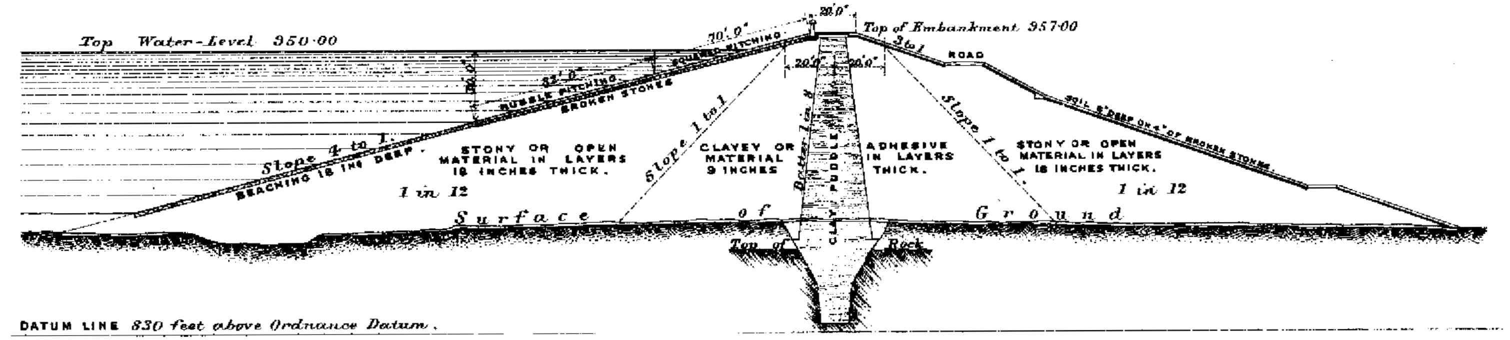
Figs 8 & 9 — 1 Inch = 6 Feet.

Fig: 2.



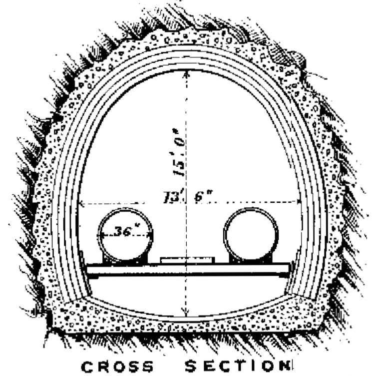
TALLA RESERVOIR: LONGITUDINAL SECTION OF EMBANKMENT.

Fig: 4.



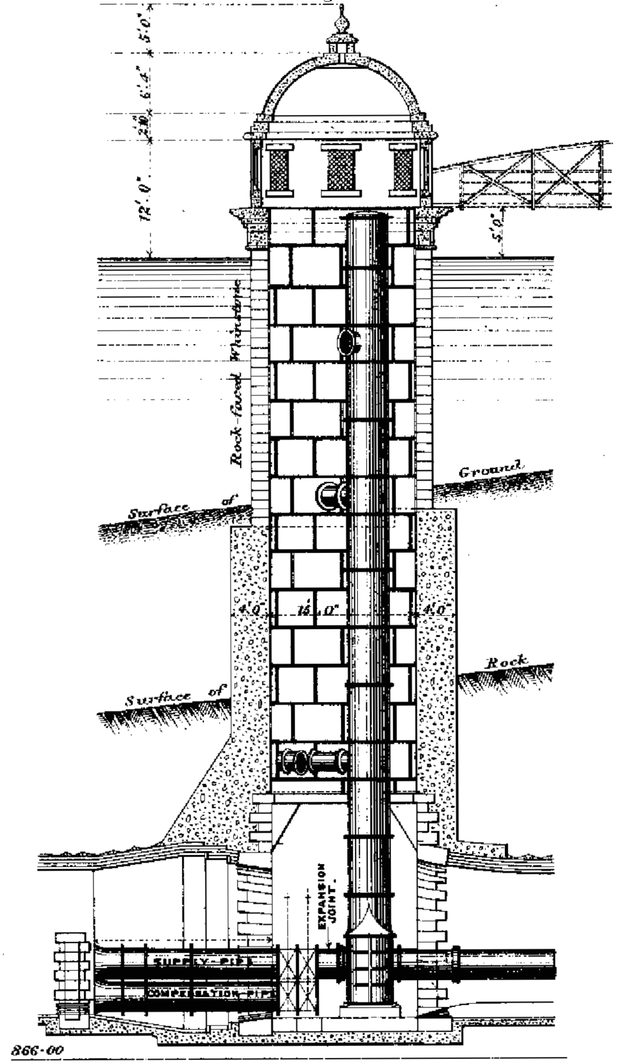
TALLA RESERVOIR: CROSS SECTION OF EMBANKMENT.

Fig: 5.



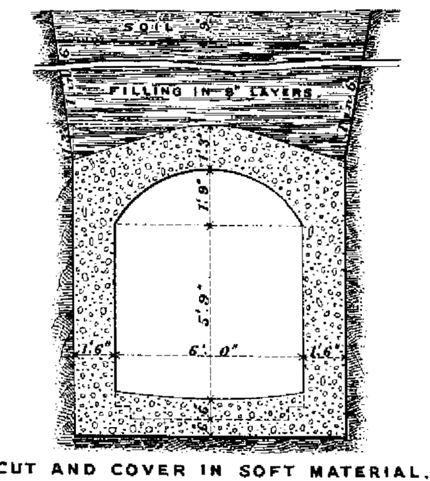
CROSS SECTION OF OUTLET-TUNNEL AT RESERVOIR.

Fig: 6.

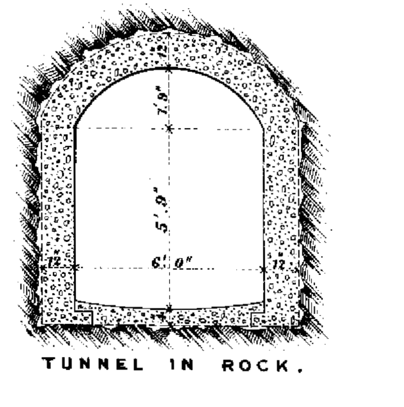


INNER SHAFT ON OUTLET-TUNNEL.

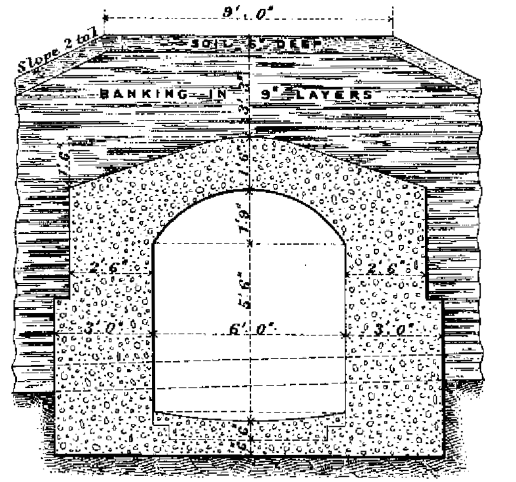
Figs 8.



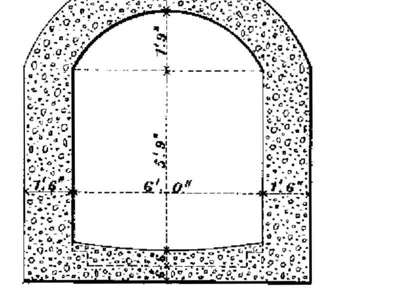
CUT AND COVER IN SOFT MATERIAL.



TUNNEL IN ROCK.



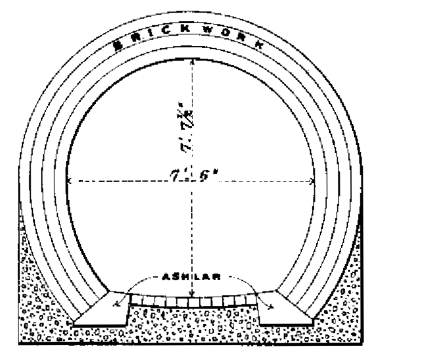
CUT AND COVER IN EMBANKMENT.



TUNNEL IN SOFT MATERIAL.

(minimum section)

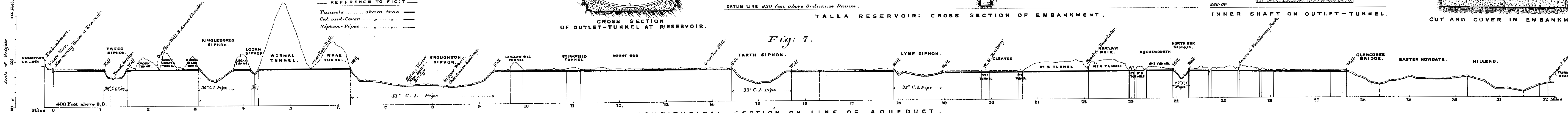
Fig: 9.



BRICK LINING IN HEAVY GROUND.

(Invert and packing afterwards made entirely of brickwork)

Fig: 7.



LONGITUDINAL SECTION ON LINE OF AQUEDUCT.

W. A. P. TAIT.

THOS KELL & SON, LITH. 40 KING ST COVENT GARDEN.