

**DARTMOUTH CORPORATION WATERWORKS.—  
LOWER NORTON WOOD RESERVOIR.—  
—TYPICAL CROSS SECTION OF EMBANKMENT —  
— LONGITUDINAL SECTION ON CENTRE OF CULVERT,—  
ROFE & RAFFERTY.  
CHARTERED CIVIL  
ENGINEERS SW 1**

**C.E.C.HULME.  
BOROUGH ENGINEER**

*It is proposed to construct an impounding reservoir in the Old Mill Valley of 26,000,000 gallons capacity.*

*The dam will be composed of an earth bank 400 ft. long and 52 ft. high in the deepest part and containing about 40,000 cub. yds. of material with a clay puddle core resting upon a concrete filled cut off trench.*

*Concrete culverts will be constructed through the dam together with a concrete valve tower.*

*The source of supply at Guttery Spring, Crosby Spring and Townstal Spring will not be used as there will be sufficient water available from the Old Mill Valley, and also it would be difficult to bring the water from these sources to one point for central treatment.*

*The service reservoirs at these points will be kept in use and will be linked up by new mains so that water can be distributed to the various points of the town under different pressures.*

*A reinforced concrete water tower is to be erected at Jawbones.*

ROFE & RAFFERTY,

**Chartered Civil Engineers.**

208, ABBEY HOUSE,

8, Victoria STREET,

WESTMINSTER, S.W.I. 12th July, 1934.

THE TOWN CLERK,

DARTMOUTH.

Dear Sir,

**WATER SUPPLIES**

Following the suggestion in my letter of the 21st April and the instructions contained in your letter of the 24th April last, Dr. Beale and myself made a complete inspection of the existing sources and works at the end of May.

Dr. Beale is reporting separately but matters have been fully discussed between us and the two reports may be taken together as expressing our joint opinion and recommendations.

**(I) SOURCES OF SUPPLY**

These have been the subject of numerous reports extending over many years, but it is necessary to repeat much that has already been said, particularly in view of the greater approach to accuracy in gauging the yields which has been possible recently, though too much reliance cannot even now be placed upon the figures stated.

The following sources are in use, either continuously or as "emergency" supplies :—

Name	Appro x. Eleva-	Summer Flow 1933 Gallons per day.		Winter Flow G.P.D
		Average of 4 months.	1 month	
(a) <b>Crosby</b> Reservoir 35,000 galls.	185.00	6,500	3,000	25,000
(b) <b>Guttery</b> Reservoir 230,000 galls.	249.00	21,000	18,000	50,000
(c) <b>Townstall</b> Reservoir 34,000 galls.	350.00	5,500	negligible	20,000
(a) <b>The Kennels</b> Emergency supply only			3,500	
(e) Townstall Hill Wood	200.00	3,250	1,300	25,000
(f) Laphorn	300.00	16,250	15,000	50,000
(g) Bozomzeal	200.00	20,000	15,000	56,000
		72,500	55,800	232,000
(h) Old mill River				
(1) Piped from springs estimated	30.00	50,000	40,000	not known
(2) From stream above Dam	57,500		53,500	ditto.
		180,000	149,300	

The minimum flows at the various sources do not occur at the same time, and the smallest total quantity obtained at any one time in 1933 was approximately 160,000 gallons per day.

Flows this summer are lower than at the corresponding period of 1933.

## (2) METHODS BY WHICH SOURCES ARE BROUGHT INTO USE

Crosby, Glittery and Townstall all feed direct into their respective reservoirs, which, however, must also be supplied in summer from other sources, the two latter by-pumping from Old Mill via Long Cross Reservoir.

Townstall Hill Wood, The Kennels (when used), Laphorn and Bozomzeal, all gravitate to Coombe Reservoir (54,000 gallons) at an elevation of 187.00, and also require making up in summer by pumping from Old Mill.

Old Mill are the only works capable of delivering water to Long Cross Reservoir (300,000 gallons), which is at an elevation of 480.00. The consumption from this Reservoir (apart from the quantities passed on to Guttery and Townstall) is limited in extent but includes the College.

Chlorinating plant was installed by the Admiralty at Old Mill some years ago and is still owned and controlled by the Admiralty, a most unsatisfactory feature.

Similar plant was installed by the Council last year at Guttery, Townstall and Coombe, but it is impossible to achieve satisfactory results at a number of small and isolated sources and the arrangement is, as intended, merely one to cope with an emergency situation.

## (3) CONSUMPTION

There are no means of definitely ascertaining the consumption.

Gaugings are taken only at the sources and as these are in excess of requirements in the winter and below them in summer, they are no direct guide.

A rough indication as to whether the gaugings are equivalent to the consumption may, however, be obtained from the pumping record at Old Mill and from this it appears that in May 1933 the consumption was approximately 220,000 g.p.d. After that date the supply was insufficient and it is a fair assumption that had the quantity been available 250,000 g p.d. would have been used during the summer months.

The average during the year is probably 200,000 g.p.d. which on the population at the 1931 Census (6,708) represents 29.9 gallons per head.

## (4) DEFICIENCY

As regard quantity therefore the existing supplies were deficient last summer to the extent of about 90,000 g.p.d. at the time of lowest total yield, and if this were all it would be a simple matter to overcome by providing storage at Old Mill.

The sources from which the water is derived are, however, such that none are satisfactory as regards quality without efficient treatment.

Satisfactory treatment requires constant supervision, and it is necessary to bring all the water used to one point to render this possible, Those of the existing sources which cannot be connected *W s*, common point must therefore be abandoned.

#### **(5) SOURCES TO BE RETAINED AND ABANDONED**

The special object of my inspection with Dr. Beale was to ascertain which of the sources, capable of use from an engineering standpoint, might be retained.

As the supply in winter always exceeds requirements, it follows that in the case of those sources which have a small summer yield any considerable expense in centralising the water could not be justified.

Under this heading come Crosby, Townstall, the Kennels and Townstal Hill Wood.

Guttery is a useful supply both as regards quantity and elevation, but its water cannot be brought to a common point for treatment without the laying of a very long main and Dr. Beale will not for one moment consent to its retention otherwise. With this opinion I concur, though with reluctance in view of the particular physical advantages of the source.

Laphorn and Bozomzeal together maintained last year a yield of not less than 36,000 g.p.d. on the average during the summer months and though they could not be retained, as at present utilised, without great expense in the prevention of pollution, the water from them can, as the main conveying it crosses the Bridge at Old Mill, be brought to the works proposed near there for storage and treatment at very little cost.

Retention of these two sources is therefore practicable though at the sacrifice of the gravity supply to Coombe.

Old Mill River, both as regards quality and its capacity for development, is the best of all the sources and could indeed be made to supply all requirements, though at considerable expense.

The schemes I am therefore now going to discuss are based upon the retention of Laphorn and Bozomzeal as sources of supply, together with a storage reservoir or reservoirs on the Old Mill River

#### **(6) ALTERNATIVE SCHEMES**

Two alternative schemes are practicable :—

(a) The construction of an "Upper Reservoir on the Old Mill River at sufficient elevation to supply Combe by gravitation, combined with a small Low Level Reservoir, or Sedimentation Tank, to deal with the supplies, now given from Longcross, Townstall and Glittery Reservoirs.

(b) The construction of one Low Level Reservoir on the Old Mill River from which (after treatment) all the water whether required for high or low level would have to be pumped.

In either case of course the existing treatment and filtration plant would require to be amplified and brought up to date.

#### **(7) SCHEME A**

So far as I am able to judge the consumption from Coombe Reservoir is approximately 2/3rds. of the whole.

On the average consumption (200,000 g.p.d.) it would therefore be about 133,000 g.p.d. but for the purpose of storage not less than 150,000 g.p.d. must be allowed for in order to cope with the summer demand, which may be 167,000 g.p.d. in this zone.

The most practicable site (if not the only practicable one) for the Upper Reservoir is just below the junction of the valleys from Hemborough and Browns Norton. There is a natural and sufficient gathering ground of about 135 acres which would require a reservoir of about 25 million gallons capacity to provide the necessary quantity.

The balance required for high level supply (including that now obtained from Glittery and Townstall) would be 83,000 g.p.d. in summer time. The summer flows from Laphorn, Bozomzeal and the Old Mill River below the Hemborough Reservoir and above the Dam at Lower Norton Wood are sufficient for this requirement, without storage, but for purposes of treatment about 7 days storage (say 600,000 gallons) would be necessary.

The water from the Hemborough Reservoir would have to be passed through Pressure Filters, which in order that all treatment is at one place should be situated at Old Mill and as the quality of the stream immediately below Hemborough and Brown's Norton is not satisfactory it would be essential to acquire these farms and change their character from what (as regards the valley) is now rich pasturage to sheep grazing.

The site of the impounding reservoir is difficult of access and its cost would therefore be relatively high. For this reason I think the cost of the works comprising the scheme, including the Impounding Reservoir, Pipeline to Old Mill, Pressure Filters, improvement of the existing filters, Sterilisation Plant, Sedimentation Reservoir and extension of the Bozomzeal and Laphorn main, together with certain necessary small works at Bozomzeal and elsewhere could not be less than **£39,000**, to which must be **added** the acquisition of the farms, easements for pipelines and land for the Sedimentation Reservoir.

#### **(8) SCHEME B.**

In this scheme the most suitable site for the Storage Reservoir would be immediately above the existing dam in Lower Norton Wood.

By such information as is available from the records, I estimate that the daily yield of the Bozomzeal and Laphorn sources, together with that from Old Mill River, to the point proposed for the reservoir, would last summer have been less than the daily requirements from the early part of June to the middle of November, a period of about 160 days, and that the total deficiency in that period would have been about 13J million gallons.

The utilisation of Townstall Hill Wood source would not have reduced this deficiency by as much as | million gallons so that it is not worth considering.

As storage reservoirs can seldom be drawn down right to the bottom and there must be some margin, the capacity of the proposed reservoir should not be less than 15 million gallons, especially as the yields this summer are so far smaller than last.

The height of a dam for this capacity would be about 35 feet and the length about 93 yards at top water level.

The site at Lower Norton Wood is reasonably accessible (assuming, as is allowed for, that the Lane to Old Mill is improved) so that the cost of construction would be lower than at Hemborough and I think the works comprising this scheme need not cost more than £24,000 or £15,000 less than for Scheme A. Further, it would be unnecessary to acquire more than the actual site of the reservoir and its immediate surroundings so that the actual difference would be much greater.

Against the lower capital cost must be set the added cost of pumping all the water. The existing pumps can, however, cope with present requirements so that the additional cost will be confined to that of another attendant, additional fuel, stores and wear and tear, which (assuming the attendant is paid £3 per week) I estimate at £250 per annum.

The Loan Charges on £15,000 at 3%, repayable in 30 years, would amount to £815 per annum, and Scheme B therefore represents a saving during the loan period of £565 per annum, and in addition the very considerable saving in acquisition of land.

After the expiration of the loan period of course the annual cost of Scheme B. will be higher by the additional cost of pumping.

Dr. Beale very much prefers Scheme B. because, *inter alia*, the water is better at the point of storage and the whole of it will be dealt with by the same treatment and filtration plant. In view of this and the figures of cost I have no hesitation in recommending it, much as I dislike, as an engineer, pumping water which could be supplied by gravitation.

#### **(9) FURTHER REASONS FOR RECOMMENDATIONS, etc.**

Having given a general outline of the proposed schemes, with their outstanding advantages and disadvantages, I think the Council will desire to have further details as to the reasons leading up to these recommendations.

Generally it will be appreciated that the existing water supplies are drawn from sources which are not free at all times from pollution. They must therefore be considered as from polluted sources and treated accordingly. Such measures cannot be left to chance and must be the subject of the strictest routine.

Neither filtration not<sup>1</sup> sterilisation plant can be worked efficiently if both the rate of flow and the quality of the water are constantly varying. This is particularly true of sterilisation by chlorine as the result is either over chlorination and consequent "taste" or under chlorination and incomplete sterilisation.

It would be impracticable to safeguard all or any but a few of the existing sources so as to make filtration, etc., of secondary importance as it would mean the acquisition of large areas of land, some of which is in process of being developed for building, and to acquire this would be to stunt the growth of the town.

The only watersheds which it is practicable to acquire are those of the Old Mill River, Laphorn and Bozomzeal

With regard to the two latter, both are now subject to pollution from the farms above them, Bozomzeal to a much greater extent than Laphorn. To deal with them so as to continue their use as at present (that is by gravitation to Coombe) would involve not only the expense of

acquiring the farms but also of drainage works and providing new filters which even then would be open to the objection of small and isolated units. In addition, storage, which is desirable to increase the available yield and secure reasonable uniformity of the rate of filtration is not practicable in either shed.

Something in any case must be done at Bozomzeal, but in the event of the adoption of either of the schemes suggested and particularly in the case of Scheme B, this need not be more than the provision of a comparatively small tank to take the worst of the drainage from the farmyard, etc. and a pipeline from this tank terminating below the intake, together with the reconstruction of all the existing manholes to the subsoil collecting pipes.

The existing filters at Bozomzeal and Laphorn would cease to function as such, but would be covered over and converted into straining chambers requiring very little and infrequent inspection.

As regards the Old Mill River, had more attention been paid in the past to diverting polluted water and the prevention of pollution, rather than to the piping for supply of relatively unpolluted water, it is probable that there would never have been any complaint as to quality, but the quantity available cannot of course be increased without storage.

The selection of the point immediately above the existing dam in Lower Norton Wood, as the site for the proposed reservoir under Scheme 13, excludes water draining from Chipton, West Norton and Lower Norton Farms. These are the nearest and therefore the most dangerous sources of pollution to the stream as a whole.

The remaining sources of pollution (apart from cattle referred to later), Browns Norton, Hemborough. and Bruckton Farms, are all high up on the watershed and at considerable distance from this reservoir.

As previously mentioned, the water in the stream immediately below Browns Norton and Hemborough, is unsatisfactory owing, not only to the adjacent farms but also because of the grazing of cattle close to the stream.

If a reservoir is constructed below Hemborough therefore the two farms must be acquired and the use of the pasture land restricted to sheep grazing (thus reducing its value) since the storage of water so recently polluted and its constant inflow into the reservoir produces putrefaction and not improvement in character, such as results from the storage of water in which the pollution is more remote.

In its passage from West Norton Wood to the western end of Lower Norton Wood, improvement of the water in the stream is noticeable, in spite of the fact that cattle have access to it on the north side about 1/3rd of the way down.

Under the Raleigh leases the Corporation had to construct cattle troughs in the enclosures adjoining the stream, obviously because it was intended to fence the latter.

The troughs were constructed but are in disrepair and the fences were never erected.

It will be necessary to repair some of the cattle troughs and fence the stream on our side for about 3/8ths of a mile.

With these precautions, and some slight measures at West Norton Farm, where a few small buildings may drain to the stream, it will be quite satisfactory to store water at the proposed Lower Reservoir (Scheme B) without acquiring any of the farms on the watershed, so long as their use remains as at present.

It cannot of course be said that this will hold good for all time, and a watch must be kept to anticipate changed conditions.

#### (10) **EXISTING WORKS AT OLD MILL**

The existing works at Old Mill comprise :—

(a) A Pre-Filter, about 22ft. x 12ft. through which all the water to be treated first passes.

(b) Two slow sand filters, each 44ft. x 26ft. or 1,144 square feet in area.

(c) A Clear Water Reservoir, stated to be capable of containing 144,000 gallons when full to a depth of 8ft.

(d) Two Sets of Oil Engines and Pumps, each capable of pumping to Longcross at the rate of 10,000 gallons per hour.

(e) A Chlorinating Apparatus, owned by and controlled by direction of the Admiralty, the Chlorine being added on the suction side of the pumps.

Each of the filters is capable of dealing, at a safe rate for such filters, with 2,400 gallons per hour or 57,600 gallons in 24 continuous hours,

## **(n) ALTERATIONS AND ADDITIONS TO WORKS AT OLD MILL**

### **Scheme A**

The existing filters could deal with the water required to be pumped for high level supply and would require only the provision of improved control to insure that the maximum safe rate of filtration is not exceeded.

The pumping plant would of course be more than sufficient for all requirements.

The new plant required at Old Mill under this Scheme, in addition to the Subsiding Reservoir, would therefore be three Pressure Filters, each of a capacity up to 3,600 gallons per hour (one being in reserve). The Chlorinating Plant at Coombe would be moved to Old Mill, the existing Chloronome there being purchased from the Admiralty.

### **Scheme B**

In this scheme all the water would pass through one treatment plant, which would consist, in order of use, of Apparatus for adding a coagulant, a Contact Tank, to permit of coagulation taking place, three Rapid Gravity Filters, each having a capacity of 5,250 gallons per hour, (one being in reserve) and possibly secondary filtration through the existing Slow Sand Filters at an increased rate, followed by sterilisation with Ammonia and Chlorine before entering the existing Filtered Water Reservoir. In this case the Admiralty Chloronome would not be required.

Secondary Filtration would properly require the addition of a third Slow Sand Filter for which there is little room and may be avoided.

The nominal capacity of each of the existing pumps is 240,000 gallons in 24 hours when pumping to Longcross and the size of the Pumping Main does not permit of both working together.

As, however, the head against which they work when pumping to Coombe is so much less than when pumping to Longcross, they could be slightly speeded up on the lower duty so as to be capable of the 250,000 gallons per day required in summer.

It would I think be possible to accommodate the additional plant required at Old Mill under this Scheme without acquiring further land there, though the site is rather cramped.

## **(12) OLD MILL LANE**

Reference has been made to the improvement of this lane, by which is meant that from Townstal Reservoir.

It is very steep and narrow and impassable to lorries so that the fuel oil has to be delivered in barrels at Townstall and taken down in small quantities by horse and cart.

If Scheme B is adopted, the quantity of oil to be delivered will be increased, and it is in any case undesirable to have important works so difficult of access.

Apart from these considerations, however, the lane is the only practicable way of getting into the valley without a long detour. Its continuation beyond Old Mill is quite good and very near to the site of the Reservoir under Scheme B, and even if scheme A is adopted quite a lot of carting to Old Mill and beyond would be necessary.

A road widening in the accepted sense is not contemplated, but the lane should be made passable and £1,000 has been allowed in each estimate for that purpose.

## **(13) INCREASE IN EXISTING COSTS OF UNDERTAKING**

In considering the additional annual cost of running the Waterworks Undertaking if either of the proposed schemes is adopted it should be borne in mind that the abandonment of five sources of supply must result in some saving, so that the whole of the Loan Charges, etc., would not come on the top of existing expenses.

In particular the £250 estimated as the cost of pumping low level water is not an addition of that amount to existing expenses because a large quantity of water is so pumped now every summer. This £250 represents an expense incurred by Scheme B and not incurred by Scheme A.

Actually the additional Attendant would probably be equivalent to the labour saved by abandoning sources and the additional fuel, etc. half accounted for by the pumping now actually done.

**(14) LEVELS WHICH CANNOT BE SUPPLIED FROM LONGCROSS**

I have made no reference to this matter as its solution would be common to either of the suggested schemes, but it is one which I think should be considered, as it has been in other proposals.

The most economical manner in which it could be carried out would be by a small Water Tower either at Longcross or at Jawbones, into which water would be pumped as required by an oil engine or electric motor, the motive power depending upon the terms for electricity.

If electricity were used the pump could be made to work automatically and indeed a "pressure tank " could be substituted for the Water Tower.

**(IS) PROCEDURE**

Since the Corporation hold leases of the water rights over practically the whole area in question, extending nearly, if not quite, to tidal waters, no question of compensation water would arise under either Scheme.

Provided the lands and easements can be acquired by agreement and facilities for the drainage works at Bozom-zeal and West Norton similarly secured, no Private Bill would be necessary, but the work could be done by sanction of the Ministry of Health.

The Ministry would require to be satisfied as to the nature of the ground under the proposed dams and that the lands can be acquired, and it might be advisable under the special circumstances to ascertain that they would accept the scheme in principle before making formal application.

The procedure to be adopted is therefore as follows:—

- (a) Decision as to whether either, and if so which, of Schemes A and B should be adopted.
- (b) Application to the landowners for permission to sink trial borings upon the site of the dam, and as to acquisition of lands and easements.
- (c) Sinking of the trial borings.
- (d) Preliminary presentation of the adopted Scheme in principle to the Ministry.
- (e) Preparation of detail plans and estimates (including tenders if desired) and application to the Ministry for formal sanction.

**(16) COMPARISON WITH PREVIOUS SCHEMES AND POSSIBILITY OF EXTENSIONS.**

The present proposals must not be confused with previous ones. They are intended to deal with existing requirements, leaving the future to take care of itself if development then renders additional works necessary.

Previous schemes have provided for future extension, and also for the scrapping of all existing works and sources, except the Old Mill River. \*

It is very unusual to construct waterworks for have requirements and the question of extension in a practicable matter cannot be disregarded.

In the case of Scheme A, future extension would bare comparatively simple as a Reservoir at Lower Norton Wood could be constructed subsequently.

With Scheme B extension would not be so simple as the Hemborough Reservoir would be expensive to construct and there is not a good intermediate site. The more practicable course would therefore be the enlargement of the lower one already constructed.

The Council may therefore desire (or the Ministry may insist) that in the event of Scheme B being adopted, the reservoir should either be made somewhat larger now or constructed so as to permit of enlargement at a later date, there being very little difference in cost between either of these alternatives.

Yours faithfully,

S. R. RAFFETY.