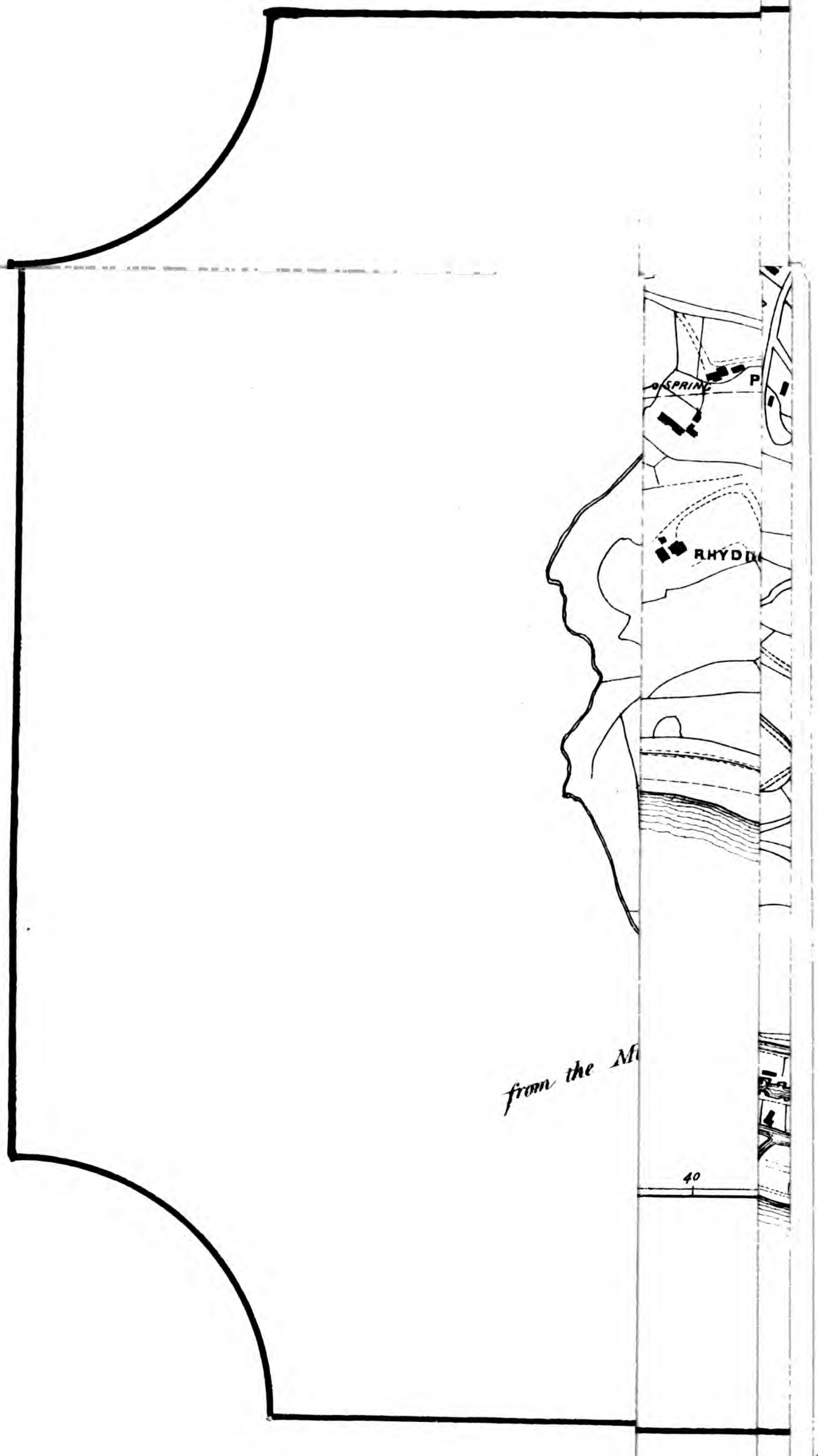
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# REPORT

ON THE

# SUPPLY OF WATER



TO THE

# TOWN OF SWANSEA.

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BY

MICHAEL SCOTT, Esq.,

*CIVIL ENGINEER.*

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# REPORT

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## *TO THE LOCAL BOARD OF HEALTH.*

GENTLEMEN,

YOU instruct me to popularize this Report, and intimate a desire that it should embrace "not only the conclusions at which I have arrived, and the data upon which these conclusions are based, but likewise the chain of reasoning leading to the results obtained."

I shall endeavour to meet your wishes; but you will permit me to observe, that the few days which intervene between the date of your Minute and the period when this document must be presented, afford but brief space in which to do justice to so wide a subject; and I trust this will be accepted as a reason for any imperfections which may appear in the fulfilment of your directions.*

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* A few proofs of this Report were originally struck off in great haste, and there being no opportunity for revisal, it was necessarily in a very imperfect form. It has since been corrected, and in some parts condensed.

Having attentively considered the circumstances of the case, I propose to divide this statement, and to describe :—

1st. The requirements, or what constitutes a good supply of water;

2nd. The existing state of the supply; and

3rd. The measures which I propose should be adopted, in order to remedy the defects of the existing service.

It will be more convenient to discuss the first division of the subject under the heads of—

Quantity,
Quality,
Nature of the supply, including Pressure, and
Price,
in reference to—
Domestic Purposes,
Trading Purposes,
Shipping Purposes,
Sanitary Purposes,
Fire Purposes,
Power Purposes.

First, respecting *quantity*. In estimating the quantity of water which should be provided for a town, it is not sufficient to base our calculations solely upon that which is distributed to other populations, although nearly equal numerically; for not only does the mode of service affect the question, but regard must be had to the character of the place, and the probable demand for trading purposes. And besides these more obvious points, it should be remembered that the inhabitants of many towns still require enlightenment with respect to the immense advantages arising from the plentiful use of water;—to be educated, if I may be allowed the expression, so as to comprehend those great sanitary truths which have long been known to medical men. For if all populations are equally alive to these truths, how does it arise, that the inhabitants of one town (Liverpool, for example,) consume about 11 gallons per head, per diem, whilst in another (Glasgow, for instance,) nearly equal in point of numbers, the supply reaches 30 gallons per head, per diem?

There are, I grant, differences between those two towns, such as the mode of service, the former being supplied upon the intermittent principle, and the latter upon the continuous; and they also differ in the quantity which runs to waste. But, being conversant with the details in both instances, I can confidently assert, that, due allowance being made for these circumstances, it still remains a fact, that the quantity used in the one town is about twice as much as in the other. Not to mention minor causes, the explanation of this is, in my opinion, as follows. In the one example cited, the people have had an almost unlimited command of water under pressure, for nearly half a century, and have become fully alive to the benefits to be derived from a copious use of it, as in bathing; whereas, in the other case, the mass of the population have yet to appreciate these advantages from experience. In the one town, in houses renting at £25 per annum, and upwards, baths are generally to be found as well as various domestic conveniences; but in the other, speaking generally, these are only to be obtained at rents of £60 or £70. That the character of the population and of the locality, and the nature of the demand for trading and other purposes, will also affect the question, seems clear; for, unless under very favourable circumstances, with respect to cost, no one would deem it requisite to provide the same relative quantity of water for a small community as would be necessary for the metropolis, there being causes of consumption in the latter which would not be found in the former.

Having thus shown, that it would not be proper to calculate the supply for any given population from the quantity consumed by any other population equal in numbers, without a careful consideration of the collateral circumstances, many of which time does not permit me to mention, I will proceed to state my views generally with respect to the quantity for Swansea.

The consumption for domestic purposes may be taken at about an average; for, though at present it is very far below this, there is no reason to doubt, that, if a suitable supply be afforded, the inhabitants will be slow to avail themselves of so great a blessing. In the same light do I look upon the requirements for trade, and assume that increased facilities will promote a more extensive demand. The quantity which will ultimately be taken by the shipping will unquestionably be very largely augmented when the new docks are completed; but, on the other hand, it should not be forgotten that a supply for shipping is comparatively a small item, even in a large port,—much less than is generally supposed. For sanitary purposes, I calculate upon a large increase, to be principally employed in cleansing paths; and for extinguishing fires, although the quantity per occasion will probably be less, from the extension of the town, yet fires may be of more frequent occurrence. For power purposes, the demand will doubtless exist and augment, whilst the ability to supply will be determined by other considerations rather than by quantity.

Having weighed the various probabilities, with reference to experience elsewhere, I have come to the conclusion, that a quantity equal to 20 gallons per diem, per head of the population, will be sufficient for all purposes; and having thus got a convenient formula, the next question to be settled is the number of individuals, resident within the district which it is proposed to supply.

Excluding the village of Morriston for the present, inasmuch as the supply for it may be considered as a separate work, the following is an outline of the district: —Referring to the general plan, we come, first, to the Town proper; next, the Franchise, in which but few dwellings are likely to require a supply, for the houses are not numerous, and are so scattered that no ordinary water rent would pay the expense of the necessary pipeage; while there is little difficulty in obtaining a quantity equal to their several wants from the small wells and runlets near at hand. Then, the Hamlet of St. Thomas, the Parish of Llansamlet, the Parish of St. John's, and the neighbourhood of the Llangefelach road, from Pen-y-filia to Swansea, in each case excepting houses situated at such a distance from the denser portions of the population as to preclude them from being supplied, with the prospect of an adequate return upon the necessary outlay. Nor do I conceive that any reasonable objection can be urged against such a course, for surely it would not be just to tax the inhabitants of the Town proper for the purpose of carrying water to isolated dwellings at a distance; and the Legislature, whilst making it compulsory to supply upon reasonable terms, has expressly sanctioned a refusal to extend the works beyond such limits as would prove remunerative.

We are now in a condition to determine the population to be supplied. And, accordingly, on referring to Appendices Nos. I. and II., you will observe, that the number, calculated from the census of 1851, was 25,100. As, however, we may assume that the works, if commenced this season, could not be completed till three years after the census of 1851, I have added 8½ per cent. to this number, being three years' increase; and I thus obtain the number 27,223, or, say in round numbers, 27,500, which I shall call the present population.

But, whilst it is essential to know the existing number of inhabitants, it is quite as necessary to look forward, and estimate the prospective number; for it would manifestly be most imprudent to construct works of such a permanent character, sufficient only for the present, without keeping in view the rapidly increasing wants of a growing community. Some parts of such works are no doubt susceptible of extension, as, for instance, the pipeage for distribution; but there are others which present no such facilities, among which are reservoirs, embankments, and leading mains; and it would be absurd to have works so formed as to be incapable of affording the requisite supply in a few years after completion. And I would here anticipate the question, which will no doubt arise, viz., "Granting the cogency of your argument as stated, where is it to stop? How many years are we to look forward?" The reply is not simple, for it involves a great number of considerations, which time will not permit me to illustrate; but to afford an idea of the principles which ought to guide engineers in such cases, I may state, that we should know the "life" of mains, the durability of the works, with the particulars of their construction, operation, and cost; and, further, we must obtain the rate of increase in the demand. Then, by calculation, a period may be found at which the loss of interest, arising from the superior dimensions of the works as proposed to be constructed now, would balance the amount which would have to be expended prior to the same prospective period, in order to enlarge the works, and make them sufficient to sustain the supply at that date.

In the case before us, I have made two estimates of the quantity of water required: the first, as before stated, being for the present population, and the second for double that number, which is a very usual allowance for new works; and as the rate of increase appears (Appendix No. I.) to be 28½ per cent. in ten years, this would show that the proposed works would be sufficient for 28 years, when the population would be doubled. But no one who has given attention to the subject can doubt that the rate of increase will, hereafter, far exceed that shown by the relative numbers at the two last decennial periods. The want of dock accommodation has pressed severely upon the trade of the town; and we have only to look at the rapid strides made by Cardiff since the docks were formed there, to be assured that a new era is about to dawn on Swansea. Again, the absence of any railway communication must have been a bar to prosperity, as may be appreciated by a reference to the changes which have arisen in more fortunate towns, from a connexion with railways, as indicated in the Registrar General's Returns. For these reasons, I anticipate that the population will be doubled, probably in 20 years, instead of in 28. And, since, calculating upon 20 gallons per head per diem, we find, that for the present supply, there will be required a daily average of 550,000 gallons, I allow 1,100,000 gallons per diem as the supply for the prospective population.

*Quality.*—I have now to describe generally the distinguishing peculiarities of water which may be pronounced good in quality, my remarks having reference chiefly to domestic use as the most important.

As a beverage, it is not requisite that water should be chemically pure, for if it were so it would be vapid. It is more agreeable to the taste when containing carbonic acid; and many people prefer our spring waters from the sandstone and chalk formations, although containing a considerable amount of saline matter, to water which contains little or none. The reasons for this may be numerous: viz.—the brightness, or high refractive power of such waters, the presence of carbonic acid, the absence of organic impurities, and, in some cases, the coolness; I say in some cases, for if drawn from considerable depths, the temperature would be higher than surface waters during a great part of the year.* But those ingredients which

* In works which were under my charge some years ago, part of the water was obtained from considerable depths; and, when snow lay on the ground, the direction of the mains could be distinctly traced, owing to the comparatively high temperature of the water passing through them.

do not greatly affect water, considered simply as a beverage, may be more injurious in reference to culinary, and are decidedly objectionable in detersive operations, from their destructive effect on soap.

The salts most generally to be found in solution in water are the carbonates and sulphates of lime, soda, and magnesia; and, of these, the compounds of lime and magnesia are the most common causes of the quality of hardness, the sulphate of lime possessing this property in an eminent degree. Water containing the bi-carbonate of lime becomes much softer on exposure to the atmosphere, owing to the escape of carbonic acid, and consequent deposition of the lime; and this salt may be almost entirely removed by mixing hydrate of lime* (or milk of lime) with the water; for the hydrate, by combining with one atom of the carbonic acid, composing the original bi-carbonate, forms simple carbonate, which, being insoluble, is precipitated, at the same time that the original bi-carbonate, being robbed of one part of its carbonic acid, is also transformed into carbonate, and deposited: the rationale of the process being, that whilst the bi-carbonate of lime is soluble, the carbonate is insoluble. This softening process has been tried upon a large scale, with considerable success; and it appears, that, in the event of organic matter being present in the water operated upon, the lime, in falling, carries a part with it, and so tends to purify the water still farther, by mechanical action. But, with the sulphate of lime, the case is very different; for no practicable means are known whereby this hardener

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* The hydrate of lime is quick lime, or carbonate of lime deprived of its carbonic acid by the application of heat, and then combined with water. It has a great affinity for carbonic acid.

can be got rid of, at a cost at all commensurate with the benefit.

I am at pains to describe the difference which exists between these two salts, because the first opportunity I had of carefully examining the springs and brooks at Swansea convinced me that there was little or no carbonate of lime in the water, although I had every reason to suspect the presence of the sulphate. I will hereafter explain the reasoning which led to the above conclusion; but, meantime, I would add, that not only is the sulphate objectionable, as an irremovable hardener of water, but it is the source of the indurated scale in steam boilers, which, by obstructing the transmission of heat, causes a loss of fuel, and is difficult to displace; whereas the deposit from the carbonate, in similar circumstances, is comparatively harmless.

Objectionable, however, as the salts of lime are in many respects, they are not without value; for, to their presence we owe that protection to metallic surfaces which is so essential in the case of pipes used to convey, and cisterns to store, water. It is well known that very soft water will dissolve lead, and several instances of poisoning have occurred from its use, after transmission through leaden conduits; but, if a few grains of lime be present, especially in the form of a sulphate, the surface of the metal is protected, and the water may pass in contact with it unimpaired in purity. The destructive power of very pure water upon iron is likewise familiar to many; and, in this case also, a few grains of lime per gallon will prevent injury to the pipe.

It would ill become me to speak with an air of authority upon a strictly chemical question, and more particularly as it is one upon which our most eminent men do not appear to agree; but, with all deference, I may be permitted to state, that my experience is confirmatory of the following views, which I understand are those held by Professor Christison, and which tend to explain the effects I wish to describe. First, with regard to lead. I believe that some of the discrepancies to be found in the evidence upon this subject are more apparent than real, and that they have arisen, in certain cases, from the presence of free carbonic acid; and, in others, from the exclusion of the atmosphere, during the experiment. For example, whilst few dispute the fact that three or four grains of sulphate of lime per gallon will prevent the water from acting injuriously upon lead, it has been stated, on the one side, that very soft water dissolves that metal, and hard water has no such effect; whilst, on the other hand, the very reverse has been asserted. Now, it appears to me, that these counter-statements may be reconciled. Assume a case in which the hardness is produced by bi-carbonate of lime; then, if an excess of carbonic acid also exists, the lead will be attacked, but, if not, it will remain untouched. Then, as to soft water;—however pure it may be, if the atmosphere be excluded, the solvent power of the water ceases. The destructive effect of the hard water described is due to carbonic acid, which forms carbonate of lead; that of pure soft water to the free oxygen of the water, which combines with the lead, forming oxide of lead. And this is quite consistent with every day observation, for that lead has a great affinity for oxygen is proved by the rapidity with which a clean surface of this metal becomes tarnished on exposure to the air.*

From the foregoing, we may easily suppose, that if two persons were to try the experiment of submiting a piece of lead to the action of hard water, and if the first obtained his sample of water from a river, whilst the second took his from a spring flowing into that river, it is quite possible that both might be correct, although the former said that no corrosion of the lead took place, whilst the latter asserted that a destructive action occurred. With respect to iron, the effects are somewhat similar. In the case of soft water, the oxygen of the air frequently attacks the metal, forming oxide of iron to an injurious extent; and, if the water be hard, the action on the pipes will generally be found to be dependent upon the presence of an excess of carbonic acid, because, provided the water have an alkaline reaction, however hard it may be, the pipes will remain uninjured. As an example of this, we may take the case of the London waters, with respect to which the Commissioners on the chemical quality of the supply to the metropolis, say:—"The pipes appear also to receive a certain amount of protection from the alkaline character of the present supply, the erosions, and bulky deposits in cast-iron

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* In soldering lead, resin or grease is usually employed, being placed upon the parts of the work to be united, so that, when heat is applied, it melts, and, flowing over the clean metal, protects it from the action of the oxygen of the atmosphere, which would otherwise tarnish the surfaces, and prevent the solder from adhering; and I wish to call attention to the fact, that the application of these substances must be made *immediately* after the surfaces to be united are cleaned, for if not, so rapidly are they tarnished, that they would have to be scraped a second time.

pipes,* which have given great trouble in the distribution of certain waters, are unknown in London."

There are one or two minor points which may be noticed in connexion with these observations; the first is, that silica is very often to be found in water otherwise pure, and that but a minute quantity of this substance appears to be sufficient to afford protection. I have also remarked, that when organic matter is present in water, there is frequently a slimy coating formed in both iron and lead pipes, which seems to have a preservative effect; and this circumstance is not inconsistent with the fact, that decaying vegetable matter, under certain conditions, causes water which contains it to act powerfully on lead.

The conclusions I arrive at from these premises are, that very soft water must be dangerous, when passing through leaden conduits, and that very hard water is objectionable, and ought to be avoided; and an example verifying the first of these statements is to be found in Aberdeen, which is supplied with very soft water, and where the inhabitants are so cognizant of this risk, that they are in the habit of allowing some part of the water to run to waste first, on each occasion when they draw a supply from the pipes,—a precaution which, combined with the leakage from the taps under constant pressure, is sufficient to remove the poisonous matter.

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* That it is the oxygen which attacks the metal seems likely, from the fact that if pieces of bright iron are placed in sea water, in its ordinary state, oxidation ensues, but if more salt be added, so as to saturate the solution, no action takes place, and the iron remains bright for months, apparently because the salt drives the air out from the interstices between the atoms of water.

It therefore appears, that the qualities which it is desirable that water should possess, exclusive of softness, may be thus enumerated. It ought to be pellucid, sweet, bright, free from organic matter, or metallic substances, well aerated, and cool. Even as a commercial question, quality is most important; and it would be easy to name many places, owing their prosperity, in a great measure, to the superior quality of the waters in the locality, and their suitableness for trading purposes, such as dyeing, brewing, &c. &c.

The most usual means of determining the relative hardness of different waters is by Dr. Clarke's test; and, as it will be referred to hereafter, I may add a brief explanation of it. This seems the more necessary, because, whilst in the hands of a competent chemist the process would give accurate results, in those of a mere dabbler in science, it is pretty certain to lead to error.

Taking a given quantity of the water to be tested, Dr. Clarke adds to it, from a graduated measure, another given quantity of a standard solution of soap, until the mixture thus formed results in a lather, which will remain permanent for—say five minutes; and, having previously determined the exact quantity of the soap solution which one grain of bi-carbonate of lime would destroy, it follows, that from the quantity of that solution which has been neutralized, the hardness of the water under examination can be discovered, or the number of grains of bi-carbonate of lime which it contained, assuming it did contain bi-carbonate of lime, and nothing else. But, not to dwell upon the careful manipulation requisite, (which can only be the result of an extended experience,) and on the importance of having the solution of soap of the standard quality, it is very seldom indeed that carbonate of lime only is in solution, it being generally associated with free carbonic acid, and frequently with other salts, all of which will more or less affect the results; and, for this reason, however convenient for indicating the hardness of water, the soap test cannot be expected to obviate the necessity for a regular analysis.

I have stated, at page 12, that I was convinced, from the appearance of the waters of the springs and brooks at Swansea, that they contained the sulphate, but little or none of the carbonate of lime; and as it is a question of quality, I introduce the exposition of my views relating to this matter here, in preference to deferring it until treating of the storage and service reservoirs, to which branch of the subject the elucidation of the point now adverted to more particularly belongs.

Proceeding upon the assumption that water containing saline matter in solution possesses high refractive power, I observed that the Swansea waters had this characteristic in an eminent degree, indeed more so than any others with which I am acquainted. It therefore followed, that some such matter was present, and in considerable quantity; and this conclusion appeared the more probable on considering the circumstance that the water under observation was taken from the streams, after a long period of drought, and was therefore in a high state of concentration. But what was the particular kind of saline matter? In order to answer this question, it is necessary to attend to the following considerations:—It is undoubtedly true, that water which contains carbonic acid, either free, or combined with bases in the form of salts, has a powerful effect in stimulating vegetable life. Discolouration, a peculiar green tint apparently due to the presence of vegetable matter, is very visible in chalk water when it is stored in small uncovered reservoirs; and, as an illustration, it will be sufficient to point to the ornamental waters in the Parks in London, which during summer I have frequently observed to have the appearance indicated. Further, that this proneness to the production of vegetation is not confined to the water of the Thames, or generated by any impurity to be found in river water, as distinguished from that obtained from wells, is, I think, readily proved, for, in reservoirs wholly supplied with deep well water the same effect is observable; and of this examples will be given hereafter.

This power of stimulating vegetation seems to be both known and appreciated; and a remarkable instance in which advantage is taken of it is to be seen at a place called Spring-head, within a few miles of Gravesend. At the bottom of a ravine, about a mile inland from the river bank, most copious springs of beautifully bright pellucid water issue from the chalk, in quantity forming a goodly stream. Throughout a part of its course, the bed is planted with water-cresses, placed in regular rows, and carefully tended like a well-kept garden; and means being adopted to retain the water at a proper depth, as well as to prevent undue velocity, which would uproot the plants, these subaqueous gardens are thus made to produce enormous quantities of cresses, which are regularly transported to the metropolis for sale. Now this water is as pure and limpid as can well be conceived, apparently without a trace of organic matter—free from taste, smell, and colour, and yet its nourishing power, as displayed in the rapid growth of the plants named, is wonderful. I had come to these conclusions some years ago, and it was with pleasure that I recently met with a complete confirmation of my views in one of the best known of the works of Sir Humphry Davy, from which the following is an extract:—

"I have found by experiment, that the water taken from the most tranquil part of the lake, (of the Solfatara in Campagna, between Rome and Tivoli,) even after being agitated and exposed to the air, contained in solution more than its own volume of carbonic acid gas, with a very small quantity of sulphuretted hydrogen. Its high temperature, which is pretty constant at 80° Fahr., and the quantity of carbonic acid it contains, render it peculiarly fitted to afford nourishment to vegetable life. The banks of Travertin are everywhere covered with reeds, lichen, confervæ, and various kinds of aquatic vegetables; and at the same time that the process of vegetable life is going on, the crystallizations of the calcareous matter, which is everywhere deposited, in consequence of the escape of the carbonic acid, likewise proceed. There is, I believe, no place in the world, where there is a more striking example of the opposition or contrast of the laws of animate and inanimate nature, of the forces of inorganic chemical affinity, and those of the powers of life." Again, on a recent occasion, when I had the pleasure of meeting Sir Henry De la Bêche, I mentioned the subject, and he remarked, that in the Island of Jamaica a similar effect is observed, to an extent enhanced by the heat of a tropical sun. At the bottom of a waterfall, formed by a stream containing carbonate of lime, the rank vegetation, combined with evaporation due to the great heat, acts so powerfully on the water as to cause large depositions of lime, the plants having the power, by virtue of their vital energy, of assimilating the carbonic acid; and the tufa thus formed, together with the vegetation itself, choke up the course of the river, to such a degree that the main body of its waters has been at different periods diverted, and made to flow over a wide extent of country.

Now, on carefully examining the springs and streams at Swansea, I observed no trace of confervæ, or the more common forms of aquatic vegetable life; hence, it was clear to my mind, that the carbonate of lime was *not* the cause of the refractive power, and, as the sulphate is one of the substances most frequently found in water, I naturally suspected its presence, which anticipation, it will be observed, is fully confirmed by Mr. Brande's analysis.

Whilst it will be evident from the facts which have now been stated with respect to the effect of carbonic acid, that when water holds this gas in solution, vegetation will generally ensue, it should be remembered that this is the case only so long as the direct solar light is admitted; for it is well known that the carbon of carbonic acid, which, under these conditions, plants have the power of assimilating, and which, as producing ligneous fibre, goes to form their bodies, is fatal to vegetation in the shade; and thus, what, under the influence of the sun's rays, the grand exciting cause of vegetable life, is their chief support, becomes in its absence a deadly poison, and the plants perish.

As connected with the question of quality, it will be well to consider the bearing of these facts upon the covering of reservoirs.

Service reservoirs, situated in the immediate vicinity of a town, are no doubt better to be covered, as the water is then protected from being rendered foul by the deposition of soot and other impurities; but applied either to these, or to large storage reservoirs, placed beyond urban or suburban limits, the resolution of the question depends, not only upon the quality, but in a great measure on the quantity and perpendicular depth of the water.

Soft water, containing little or none of the salts of lime in solution, does not generate vegetation rapidly, and will remain pure, when exposed to the direct action of the sun's rays, for a much longer period than most hard waters; and, when we have soft water in bulk of considerable depth, as in large reservoirs, it will remain pure and unchanged for ages. In confirmation of this, I need only refer to the English and Scottish lakes. But with hard water, which contains carbonic acid, free or combined, the case is very different. I would here refer to two classes of waters extensively used in this country, namely, the water from the red sandstone, and from the chalk formations. The former is beautifully bright, and perfectly pellucid, when first raised from the wells sunk in the rock, in the interstices of which it may have lain for centuries in a similar condition, and it can be kept clear and sweet for a long period (I have tried it for many months) even in shallow tanks, and perfectly stagnant, if the receptacle be roofed, or in other words, if the water be protected from the rays of the sun; but, remove the covering, and what a change! I will quote an instance which came under my notice some years ago:—A tank, 93 feet in diameter, and 12 feet deep, lined with brickwork, receives the water, which is pumped up by the engines at the Bootle Station of the Liverpool Waterworks;

when roofed, so small was the deposit of sand (for there was no *mud* or other impurity) that it needed not to be cleaned once in several years. But the roof, having decayed, was removed; vegetation commenced and proceeded, until plants were seen growing, the stalks of which, when floating in the water, appeared as thick as a man's arm. These became decomposed; and when the tank was emptied, which, during summer, was generally every eight or ten days, a mass of the foulest imaginable matter, teeming with myriads of worms and creeping things, covered the bottom to the depth of several inches. Indeed, so offensive was this vile residuum, that the stench was almost intolerable; and yet, each day during the whole period, above half-a-million of gallons of perfectly bright, sweet, pellucid water, fresh raised from a depth of 150 to 600 feet in the rock, passed through the tank, being a quantity sufficient to fill it to the height mentioned, once every 20 hours; thus proving, that motion, or change of water, is *not* the most important part of the matter.

The following analysis of this water is taken from Mr. Stephenson's Report on the supply of water to the town of Liverpool, page 50:—

"Water from Bootle.—One gallon, by evaporation to dryness, yielded 24 grains of residue, which consisted very nearly of—

| | | |
|---|---|---|
| Sulphate of Lime | 3·31 | grains. |
| Carbonate of Lime | 7·10 | „ |
| Carbonate of Magnesia | 6·93 | „ |
| Chloride of Sodium | 3·37 | „ |
| Silica | 0·48 | „ |
| Organic Matter, traces of Potassium, and loss | 2·81 | „ |
| | 24·00 | |

Hardness, according to Dr. Clarke's standard, 17·71."

In another reservoir, belonging to the same works, supplied from Green Lane pumping station, the same thing occurred, but not so rapidly, in consequence of the smaller proportion of carbonic acid present, and the greater depth of the water, which, when the reservoir was full, was 17 feet.

The capacity of this reservoir was ten millions of gallons, whilst about one million gallons passed through it in a day, or one-tenth part, and it presented, when full, an area of nearly 12,000 square yards.* The analysis of the water here spoken of, taken from the same Report, is as follows :—

"Green Lane.—One gallon yielded, by evaporation to dryness, 13·60 grains of residue, consisting very nearly of—

| | | |
|---|---|---|
| Carbonate of Lime | 5·26 | grains. |
| Chloride of Sodium | 2·66 | " |
| Sulphate of Soda | 2·23 | " |
| Silica | 0·64 | " |
| Organic Matter, and loss | 2·81 | " |
| | 13·60 | |

Hardness, according to Dr. Clarke's standard, 5·26."

But, although it is essential, in such cases, to defend the water from the direct solar rays, it is necessary that the air should not be excluded, otherwise the softening effect on the water caused by the escape of carbonic acid would be prevented, as well as the purifying influence of

* When this reservoir was under my charge, (five years ago,) being satisfied that a fixed roof to overspread such an extended space would have been a work of inordinate expense, I designed a floating cover, which should rise and fall with the water, and which would evidently have afforded the protection required, at far less cost.

the atmosphere when organic matter is present. For organic matter becomes oxidized, when in situations to which the air has access, as is exemplified by many streams in which the water contains peat in the higher parts of their course, but becomes purified to a considerable extent after flowing over some miles of good ground.

It may be added, that when water necessarily contains organic matter, the existence of plants and animalculæ may be advantageous, as, by feeding upon it, they prevent the deleterious effect produced by its decomposition, and the consequent generation and evolution of noxious gases; and, under such circumstances, the presence of carbonic acid in the water may be desirable.* These observations are evidently, in a great measure, applicable to conduits for the conveyance, as well as to reservoirs for the storage, of water containing such matter.

*Nature of the Supply.*—There can hardly be two opinions respecting the requirements, either as affecting the consumers or the supplying body, seeing, that *in cases where the full benefits are to be realized*, continuous supply under pressure is better than a supply on the intermittent principle. But, whilst this may be readily conceded, I must be permitted to add, that much misconception has prevailed respecting the relative advantages of

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* In illustration of this, I could point to instances of reservoirs, in which, the water supplying them being contaminated with sewage, vegetation was encouraged with beneficial effect. On one occasion these ponds were cleansed, and the vegetable matter removed, and with this result, that the water remained subsequently in a very inferior condition, until, vegetation again appearing, a change for the better took place.

the two systems; and, for this reason, I propose to enter somewhat into detail, for the purpose of pointing out their distinctive peculiarities, with which experience has made me familiar. As a consumer's question, the principal advantage anticipated from the introduction of continuous (or constant) supply is, that house cisterns and butts would no longer be required, and therefore, that not only would the cost of the internal fittings, original and annual, be diminished, but that the water would be obtained for use in a more pure and desirable state. With reference to these anticipations, I would observe, that, in the case of the poorer class of houses, they would be realized, but with regard to the dwellings of the middle and upper classes, the amount of benefit would not be so great. For, assuming that there could be no object in wishing for an ample supply unless it were intended to make extensive use of it, I must conclude, that water-closets, baths, and other conveniences, would be generally introduced, and that water would be laid on to every floor, so as to be every where and always available, under pressure.

Now, it appears to me, that when many persons picture to themselves the enjoyment which such perfect arrangements would afford them, they forget to reckon the cost; or, rather, basing their anticipations upon the erroneous statements which have appeared from time to time upon this subject, they believe that their visions can be realized without any additional outlay whatever, or probably at a diminished rate of charge. Let us look more closely into the matter. Suppose the case of a town which has hitherto been supplied upon the intermittent system, but in which the inhabitants are now to obtain water under continuous high pressure. The old cisterns, formerly required, would be dismantled, except such as could be adapted to serve the water-closets and baths; for, with respect to the former, I have never met with any description which operated satisfactorily without a cistern; and, with regard to the latter, particularly shower baths, it would be rather disagreeable to stand shivering in the cold, between every pull, waiting until the small supply pipe furnished the quantity for another discharge; while even with the plunge bath, considerable time would frequently elapse before the body of water required could be delivered, because the pressure may be diminished, if water is being drawn off below.* Secondly, it should be noticed, that in the great majority of cases, the lead pipes would not be capable of sustaining the increased pressure, chiefly on account of their being too light and thin, but partly from the defective system of manufacture practised until recently.† For, even assuming that the elevation of the source from which the supply was formerly delivered remained unaltered, the chances are, that the pressure due to that elevation never was placed upon the pipes, because, in the intermittent system, all the tenants in the district under service would be drawing at once, some below, and some above, and thus numerous taps would be open during the

* Perhaps the best evidence of the necessity for cisterns, arising from the difficulty of sustaining the pressure in the upper floors of high houses, is to be found at Glasgow, where, with great capabilities on the part of the waterworks, cisterns are always provided, in order to prevent disappointment in this particular.

† The method of forming leaden tube, at no distant period, was by the drawbench, whereby any minute pore in the original casting was elongated into a split, dividing the pipe in the direction of its length, and it is only within these few years that the more perfect plan has been pursued, of forcing solid lead through a die by hydraulic pressure.

time the water was turned on; but on the constant system, the case is very different, for if not in the daytime, at all events during the night, every pipe would be subjected to very nearly the total pressure due to the head. Besides this, the concussions to which the lead pipes are subject in the lower parts of the houses, on shutting the taps, is generally very much greater under constant supply than under the intermittent system; because in the former the pressure is derived direct from the mains, and in the latter it is only that due to the height of the cistern in the house.

It ought also to be borne in mind, that, to take full advantage of the new supply, additional apparatus, such as sinks, pipes, &c., must be provided, not to mention baths and water-closets, which have been supposed to exist in each house. Now all of this work will obviously be of an expensive character, having to be calculated, not to sustain a limited pressure for a few hours every other day, but a constant, and very high pressure.* For, be it remembered, the supply is to be available at all times on the upper floors, and to sustain this condition will, of necessity, involve a very high pressure, seeing that parties may be drawing water below at the same moment that it is required above.

The alterations in the structural arrangements, to be effected at the cost of the house-owner or tenant, will therefore include:—1st. Either the adaptation of the old cisterns, or, what in most cases will be the cheaper plan,

* I do not mean, that the risk of bursting the pipe is augmented by the pressure being constant, but that the risk of injury to the house and furniture, if the pipe does burst, is much increased; for although stopcocks may be provided to shut off the water in the event of an accident, still, from long disuse, they are seldom in working condition.

the erection of new ones; 2nd. The renewal and extension of the leaden communication and service pipes; 3rd. The fixing of new taps, sinks, and similar apparatus; and, 4th. Supposing them not to be already provided, the erection of baths, water-closets, and other conveniences, with all the accompaniments of overflows, soil pipes, &c. &c. Nor will the expense end here; for the continuousness of the supply, combined with the increased pressure, renders it necessary to keep the taps in much better condition; and experience shows that the requisite repairs are costly, especially if the water contains sand or other matter, which, by attrition, expedites the decay of the moving parts. Indeed, I have known cases in which it was found cheaper to provide cisterns, into which the water was delivered in the first instance, and from which the various taps were fed, the pressure upon them being thereby reduced.

Of course, in the case of the introduction of water for the first time, where no works existed previously, part of what has just been stated would not apply; but I have thought it right to mention these facts, because many large towns are supplied on the intermittent system, and to this Swansea is not an exception.

It here occurs to me to be necessary to guard against misapprehension, or a misconstruction of the foregoing remarks; for I wish it to be observed, that I am not arguing that the intermittent system is equal, much less superior, to the constant system, *per se;* but I have been endeavouring to shew, that such comforts as water-closets and baths are not necessarily a part of the constant, any more than of the intermittent system, and therefore that their enjoyment must involve expense in any case.

Still, considered as a consumer's question, I would now allude to some advantages attached to constant supply, which do not involve a *per contra*, in the form of increased outlay, &c.

In the dwellings of the poor, where no apparatus is generally provided beyond a single tap, constant supply confers a great benefit, by substituting one service reservoir, or one very large cistern, for numerous small ones, or butts; and, the former being placed under competent management, the arrangement is better and cheaper, besides affording infinitely less opportunity for the defilement or deterioration of the water. Moreover, a sufficient quantity is rendered available at all times, which is seldom the result on the intermittent system.

The same effect follows in the case of the supplies required by manufactories, such as breweries, where constant supply saves the expense of large vessels, and reduces the dimensions and cost of pipes, cocks, and similar fittings,—affords facilities for feeding boilers, and filling them up when cold, without pumps, &c. &c. The large tanks heretofore employed in such establishments were no doubt useful, for measuring the quantity taken, and determining the charge made for the supply; but Mr. Siemen's beautiful invention bids fair to attain this object in a less expensive manner, by providing a very perfect water-meter,—a desideratum long felt.

Amongst the more recent applications of water wherein constant supply (under pressure, of course,) possesses great superiority, I may advert to the washing of railway carriages, as originally proposed and carried into effect by the writer, and which will no doubt be more extensively adopted when more generally known.

For supplying shipping, including filling casks and tanks, washing decks and holds, filling new vessels to test their tightness, &c., water always obtainable under pressure is very valuable, inasmuch as smaller hose may be used, fewer men employed, and less time occupied in each operation, all of which contribute towards saving money and promoting convenience; and, as illustrating one point only, I may state, that as water is generally the last thing taken on board, prior to sailing, amidst much hurry and bustle, without very considerable facilities vessels frequently lose the tide, as it is called, or find the dock gates shut before they get out, which is a very serious matter, especially in the case of emigrant vessels, as it will probably involve a delay of twenty-four hours.

Hitherto we have considered the subject of constant supply as a consumer's question; but there is another aspect in which it ought to be viewed, namely, as affecting the supplying body, and to them there are several advantages, the most prominent of which I will notice. The first is, that fewer men are required to attend to complaints of non-supply, and as turncocks in connection with the service for domestic and trading purposes: for, in the case of constant supply, the tenants have only to help themselves, whereas with intermittent service, the water has to be turned on to different districts, at different periods of the day, and the turncock requires to see that the tenants are supplied, before he shuts off the water again. The second point is, that, with constant supply, many of the pipes may be smaller, if cisterns are provided for water-closets and baths, because these receptacles become filled during the night; but, if no cisterns were provided, and if the inhabitants were to avail themselves fully of the water for bathing, &c., the difference in the dimensions of the pipeage would not be great, inasmuch as the demand for water, being general at certain periods of the day, the quantity passing through the pipes requires to be correspondingly large, if the pressure is sustained so as to reach the upper floors of the houses. Thirdly, with constant supply under high pressure, that waste of water is saved, which arises, under the intermittent system, from the poorer class of consumers throwing away the surplus quantity they may have stored in various vessels from one water day to another; and when pipes are carried *into* each house, the very force of the water tends to prevent the inhabitants from permitting it to run to waste; but, on the other hand, with outside or stand pipes, and even inside, unless taps of a superior kind be provided and kept in good condition, the waste from them may be, and frequently is, enormous, especially in the case of ball cocks supplying cisterns provided with overflows. Fourthly, the constant pressure system has this advantage, as respects the landlords of weekly property, who may be considered as the supplying body; that it, in a great measure, prevents the tenants from abstracting the fittings, as is not unfrequently done under the intermittent system, thus furnishing the landlords with a reason for objecting to supply the necessary apparatus. Fifthly, a fertile source of annoyance under the intermittent system, namely, the contamination of the water by gas drawn into the pipes by the vacuum formed when the supply is shut off and the pipes emptied, is avoided under constant supply; because, however saturated the ground may be with gas, it can find no entrance into the mains when they are kept always full. Sixthly, the strain upon the service pipes is not so great on the constant, as on the intermittent system; for, on the former, it is more nearly that due to the simple pressure, whereas, on the latter, concussions frequently arise, in consequence of the sudden admission of water into pipes either partially or completely empty, although this effect is modified by the use of cocks, which open gradually. Seventhly, the oxidation of the iron of which the pipes are composed, arising from the action of the oxygen of the atmosphere, is considerably less when they are constantly charged.

On the other hand, the intermittent system affords greater facilities for repairs to the service and communication pipes, and, in addition, it is free from the following disadvantage, which is of a serious nature. In many cases, especially when the supply is given by means of stand-pipes, it is hardly practicable to recover the water rents from many of those served, because, so long as one pays, the supplying body is precluded from cutting off the water from others who may wish to avoid so doing. But this cannot occur to such an extent with intermittent service, because not only is the presence of the turncock a check, but as the water is left on only long enough to serve those who do pay, there is no time for those who do not to obtain a supply.

For sanitary purposes, such as washing courts and paths, and watering streets, all of which are more cheaply and effectually done by a jet of water than by any other means, pressure is indispensable; and the same remarks apply to the cleansing of slaughter-houses, markets, &c.

As I have paid some attention to this subject, the present opportunity may be taken to point out some of the principal advantages of the system of watering streets by jet, as compared with the old method of water carts; and, as a ready means of doing so, I shall quote in substance from a Report made by me some years ago, merely varying it according to the suggestions of recent experience.

The objections to the use of water carts are, the valuable space they occupy in crowded thoroughfares, either when being filled or when in motion, and the slowness of their operation. The jet system, on the contrary, offers little interruption to the traffic, and is infinitely more effective, because the streets may be much more thoroughly drenched at one operation, without a corresponding loss of time. But these are minor advantages, when compared with the facility which is afforded by this system for washing, not only the streets, but also the paths, courts, and narrow passages, where no cart could enter, although it is in such passages that the detergent process is more particularly required: and, as an important collateral benefit arising from the jet system, I may mention that there would be a large number of men trained to use the branches and hose, who would form a valuable body in the event of fire.

There is one question, however, which may naturally arise, and which deserves attention, viz.—"Why is watering by jet not more generally practised in towns where an ample supply under pressure may be had?" I conceive that one, it might almost be said *the* reason, is, because there has been no means of controlling the extent or force of the jet; for, if the water flowed with great velocity, then, although it enabled the operator to sweep or include a large area of street, still he could not water the part near himself, except in one of two ways,—by allowing the jet to rise perpendicularly and so descend with great force, or by directing it downwards—either of which would disintegrate the surface of the street, at all events, if composed of macadam. I shall now explain the method which I adopted for overcoming this difficulty, without diminishing the force of the water required to give the necessary range. It consists of a branch furnished with a small wheel, which on being turned shuts or opens a valve inside the pipe, and thereby regulates the stream of water; and, the valve being nearly in equilibrium, is quite easily moved, whatever pressure of water there may be in the main. Here then, we have all that is required to remove the only objection worthy of notice to the jet system. The water can be made to fall 100 feet off, or drop gently at one's feet. It can be made to flow with full force, or be shut off entirely in a moment—in fact, it is so perfectly under control, that neither danger nor annoyance need be apprehended.

Lastly, for the extinction of fire, great pressure is essential, if the water is to be applied without the intervention of a fire engine. Water has for a long period been applied direct from the mains for this purpose, (I remember it being so used many years ago in Glasgow,) and the only improvement more recently effected consists in the employment of greater pressure, which confers the following advantages,—First, it enables the operator to reach the upper portions of the building on fire, and frequently this cannot be the case with limited pressure, because the intense heat of the burning mass prevents a very near approach to it. Secondly, great pressure gives power sufficient to break the glass in the windows, otherwise a dangerous operation, and yet often a most necessary one, for the admission of the water into the interior of the building. Thirdly, pressure and quantity are, to a certain extent, convertible terms; and as it has been found that to ensure the efficiency of water applied direct from the mains, comparatively very large pipes are required, even with considerable pressure, it follows that, with the ordinary service pipes laid for domestic supply, either very great pressure must be used, or it will not be possible to dispense with fire engines; since a much smaller quantity would be discharged through a single jet and length of hose than would flow into the engine tub at the level of the street. In the case of a fire on ship board, in the docks or harbour, where the usual course of scuttling the vessel is expedited by pouring in water from above, high pressure, as increasing the quantity, is most important.

A really good fire service is no doubt most desirable everywhere, as tending at once to prevent accidents to persons, and reduce the expense of insurance; but, at the same time, it is obvious that the arrangements which would be remunerative in connection with large ranges of warehouses, filled with valuable merchandise, would involve a heavy tax upon the proprietors or tenants of ordinary dwelling-houses; and believing that prevention is better than cure, I am of opinion that the best security, both to person and property, is to exercise greater care in the original construction of all buildings, so as to render them fire-proof, and thereby reduce the risk, which would then be confined to the contents.

With respect to the application of water for power purposes, there are many cases in which it is a more suitable agent than steam for giving motion to machinery, and amongst these may be instanced;—cases where the power required is too small to admit of the profitable application of steam;—cases in which power is only required intermittently, or at intervals;—cases in which the *locale* of the power is variable, including cases in which the power-engine must be portable;—and cases in which the presence of fire would be dangerous, or in which the presence of water would be advantageous. Although a singularly interesting branch of our subject, it is obvious that the limits of this Report preclude me from entering fully into detail, and I shall, therefore, confine myself to a simple illustration of these cases. In the year 1846, I submitted to a certain body, a statement, containing a proposition for the establishment of works at Liverpool, in order to provide a supply of water for power, fire, and sanitary purposes. The locality was peculiarly suitable for such arrangements as I proposed, seeing that there are many hundred warehouses, crowded into a small area, and containing a very large amount of valuable merchandise, the insurance upon which was effected at high premiums, whilst, at the same time, from the great elevation of the buildings, the mere act of raising and lowering the goods required the labour of a very considerable number of men. Water for sanitary purposes was also in request; and, these being the conditions, my idea was to erect powerful steam-engines, to lay mains throughout the warehouse district, connected with an elevated reservoir, and to pump water from the river continuously into the mains, under the great pressure due to that reservoir. By these means, a supply for sanitary purposes would have been obtained, and a very superior fire service; but the difficulty would then arise, how could the expense be borne? In this way; I proposed, that in each warehouse, a small machine, not unlike a high-pressure steam-engine in form, should be erected, to be moved by water obtained from the fire mains, and employed in raising and lowering the goods to the several floors; and that a charge should be made for the water in each case, in proportion to the quantity consumed, which would be easily discovered, by registering the number of strokes made by the machines. By such an arrangement the cost might be defrayed; and although fires take place at irregular intervals, there would be continuous use for the water, and the pumping machinery being kept regularly at work would have been always in effective condition. The scheme was also intended to provide a supply of motive power for cranes at the docks; and it was afterwards extended, so as to embrace hoisting machinery to be used on board of ships in the various basins, for unloading their cargo, &c.; the water to be conveyed across any intervening vessels by means of flexible pipes.

The foregoing illustrates the whole of the cases mentioned; but I would direct special attention to one, as perhaps not so prominent as the others, viz.—that wherein danger is to be apprehended from fire, which prevents the use of steam-power in or near warehouses. In conclusion, it will be observed, that for power purposes, pressure is quite essential, because if the pressure is small, the quantity of water required will be proportionately great; on the principle, that it requires 100 lbs. falling through one foot to produce the same amount of power as would be developed by 1 lb. falling through 100 feet.

I have been informed that hydraulic power is to be employed at the Swansea Docks, and I have made allowance for it in my estimates.

It will be unnecessary to extend these observations, having said enough to show that a constant supply of water under high pressure is exceedingly desirable.

*Price.*—In another place, when speaking of quality, I have stated, that it is more a comparative than an absolute question; and the same remark applies to price, so far as it is governed by the cost of obtaining a supply; for it is evident, that an expenditure which, in one instance, would suffice to obtain an excellent supply of water, may, in another, be wholly inadequate. One town may be situated upon the banks of a lake, or pure river, whilst another may be placed at a considerable distance from any suitable source; then, I argue, that it would be absurd to institute a comparison between the charges for water in these cities; for what would be an exorbitant rate in the one case, might be a very moderate charge in the other.

I would also assume, as an axiom, that water seems to be valuable pretty nearly in proportion to the inability of people to pay for it; for it is admitted, that, for all personal purposes, a plentiful supply of water is of more importance to the poor than to the rich, even up to the luxury of a bath. Nor need I dwell upon the loss to the poor, occasioned by the necessity of fetching water from a distance; for this, with many other points of a like nature, is too well known to require any illustration from my pen. I shall, therefore, proceed upon the assumption, that it is quite necessary to provide a supply for the poorer classes, at the cheapest possible rate.

The great difficulty in effecting this, lies generally in the fact, that many of the smaller class of houses are let to weekly tenants, which renders it impracticable for the supplying body to collect the water rents; and also, that although large abatements are offered to the landlords, they are frequently unwilling to incur the cost of the requisite fittings, and become responsible for the rates.

No doubt all local Boards of Health, under the Public Health Act, possess powers to compel persons so situated to take water, but only on condition that it can be supplied at a rate not exceeding twopence per week, or 8*s.* 8*d.* per annum; and if, from the expensive character of the works, the supply could not be afforded at this rate, then it would necessarily involve the taxing of the rich, in order to supply the poor. I confess myself unable to appreciate the force of the arguments in support of such a course; for, not to mention the fact, that in nine cases out of ten the benefit goes to the landlord, and does not reach the tenant, I do not comprehend why the poor should be exempted from contributing their proportion.

The strongest case in which the landlords of small houses have repudiated the moral obligation under which they lie in this matter, is perhaps, in Glasgow, where the Water Company for years supplied nearly 100,000 individuals without payment, simply because it was impossible to collect the money; and, as a natural result, this Company have been compelled to charge what might otherwise have been considered an unreasonably high rate for the better descriptions of property. Here, then, we have a test of the desirableness of exempting the poor from the payment of water rates; and I need only refer to any one, who is conversant with the condition of those classes in Glasgow, to prove that no benefit commensurate with the cost has reached the tenants.

But, it may be asked,—"Cannot some method be discovered of compelling landlords to do their duty in this particular?" And I may answer, that many arrangements have been suggested, but none were found free from grave objections when attempted to be put into practical operation. I believe there are but two ways in which the evil can be remedied; either by convincing landlords that proper provisions made by them for the supply of their tenants would be remunerative, as inducing superior habits in the tenants themselves, and thereby not only affording greater security for the rents, but producing a willingness on the tenants' part to submit to some additional charge for the water; or, by obtaining powers to levy a compulsory rate upon house property, whether the water be taken or not.

Cheapness, as inducing a larger consumption, should also be aimed at for trading supplies; for as no one denies the desirableness of extending trading operations, so it should be remembered how essential to many manufactures is a plentiful and cheap supply of water.

Even at the best, the cost of water is a large item in many trades, brewing for instance, and entails considerable expense upon the shipping frequenting the port; and, therefore, in seeking to encourage commercial enterprize, it would be wise to reduce the charge to a minimum; whilst for sanitary purposes, a high price would prevent the employment of water to such an extent as might otherwise be desirable. As to power, of course high rates of charge would be fatal to the employment of water; and it ought not to be forgotten, that all these react upon the price for domestic purposes, inasmuch as a certain revenue must be raised, whilst a largely increased sale would not add materially to many items included in the annual expenditure.

## EXISTING STATE OF THE SUPPLY.

THIS division of our subject may be dismissed in few words; for, merely drawing attention to one or two of the most salient points, I would refer to the Report made to the Arbitrator, (page 72,) for my views respecting the manner in which the Company have fulfilled their engagements to the Legislature, and done their duty to the public of Swansea.

It will be seen from that statement, that hitherto only a small part of the district, containing a population of about 5,600 persons out of 25,000, has been, even partially, supplied,—the great majority being compelled to procure water from a distance; and, with the existing reservoir space, the supply even to this limited number cannot be guaranteed, for we have it on record, in Mr. Clarke's Report, that the supply failed. But, considering that the gentlemen I have the honor to address are no doubt better informed than I can be, upon this matter, it would seem useless to spend time in proving that which is admitted and notorious; and I shall, therefore, (with the exception of one thing which is the subject of a special reference,) content myself with submitting, as susceptible of the most ample proof, that as regards the town of Swansea, the supply from the existing works is deficient—in *quantity*, in *quality*, in *pressure*, in *constancy of service*, and is too high in *price*.

The special matter above alluded to is contained in the following Resolution of your Board:—

"That the offer made by Mr. W. H. Smith be entertained by this Board; and that his statement and proposals be submitted to Mr. Scott, our engineer, with directions to confer with Mr. Smith's engineer, and then to report and advise this Board generally thereon, in order that this Board may be enabled to give Mr. Smith a definite answer at the next monthly meeting, or earlier, if practicable."

Upon this I have the honor to report, that, having conferred with Mr. Smith's engineer, and carefully considered the subject, I am decidedly of opinion that Mr. Smith's offer to sell his reservoir at Cwmdonkin to the Board should not be accepted, inasmuch as it would not be advantageous to the public.

For the more general reasons which involve this conclusion I have to refer to the subsequent part of this Report; but I may here state, first, that I entirely differ from the opinions contained in the following passage, in Mr. Smith's letter to the Board, dated 22nd March, viz. —"The reservoir is situated at a level, and is of sufficient capacity to command and contain a constant supply of water, at a high pressure, to the whole of the upper part of the town; and, from the advanced state of my works, that supply may be given in the course of two months from the date of your purchase." On the contrary, I feel certain that the said reservoir would not afford a constant supply of water, at high pressure, to the whole of the upper part of the town, being deficient both in level and capacity; nor do I think that if the reservoir were sufficient in these particulars, such supply could be given in the course of two months from the date of purchase.

1.—With respect to level, I find that this reservoir is two feet *below* the high part of the Cwmbwrla road, and ten feet *below* Mr. Brock's gate, Mount Pleasant.*

2.—With regard to capacity, assuming the water from the Fynone Brook to be joined to that flowing down the Cwmdonkin Brook, the quantity available, during a dry season, would not exceed 20,000 gallons per diem, which, judging from observations made in the locality, that the duration of such dry seasons should be taken as extending over a period of three months, and granting that the reservoir was full to commence with, would afford a supply equal to about 85,000 gallons per diem, or sufficient for 850 houses.

3.—As it is admitted, on all hands, that additional reservoir space must be provided for the supply of the town, I am of opinion that storage equal to that which would be afforded by the Cwmdonkin reservoir will be more cheaply obtained elsewhere.

4.—Mr. Walters, a gentleman resident in the immediate neighbourhood of the reservoir, informed me that it was not tight, and that the whole water which fell during the heavy rains early in February had leaked out; I have since been favoured with a copy of Mr. Jones's Report, wherein the reservoir is described as perfectly water-tight.

5.—I have very little faith in the permanency of the Cwmdonkin stream, having been informed that it has

* I find that these levels do not agree with the figures given in the Report upon this reservoir by Mr. Smith's engineer, and for this reason, that he assumes the level of the top of the reservoir, whereas I take the bottom; but it should be remembered, that if we are to calculate (as I have done) upon the capacity of the reservoir being available for storage, we must take the levels I have given.

been gradually, but certainly, diminishing in volume for the last twelve years.

And, lastly.—I consider it exceedingly desirable to concentrate the works which may be employed for the supply of the town, so that the charges for superintendence may be kept as low as possible; and I am, therefore, of opinion, that the existence of storage reservoirs at a distance from each other is to be deprecated.

In reference to the statement and proposals mentioned in the Resolution as made by Mr. Smith, and on which I am called upon to advise, the only information before me consists of the following memorandum:—

"1. The property I propose to sell to the Local Board consists of 7½ acres of freehold land, at Uplands, upon which my reservoir has been constructed.

"2. All, or as much land as may be required, of a field above Fynone, through which the Evan John spring flows, and which forms part of the Town Hill estate. This property is held under lease for 99 years, but, if necessary, the fee may be purchased.

"3. The amount necessary for completing all arrangements, for the effective supply of the upper part of the town, £2,880. This sum includes a tank above Fynone, completion of existing reservoir, and list of pipes, mains, and cocks, as per memorandum.

"W. H. SMITH."

The first clause consists of an offer to sell certain land at Uplands; and so far as the construction of waterworks for the supply of Swansea is concerned, I do not advise that such land should be purchased, because I do not think it will be required.

With respect to the second clause, containing an offer to sell land at Fynone, pending the decision of the Board upon other and more important questions connected with the water supply, I do not feel myself in a position to advise upon this point.

With regard to the third clause, containing a statement of the sum which Mr. Smith calculates would be sufficient to supply the upper part of the town, I have only one remark to make at present, which is, that the amount would, according to my experience, be wholly inadequate to effect that object.

## PROPOSED NEW WORKS.

We have now arrived at the third and last division of this Report, namely, the measures which I propose should be adopted, in order to ensure a proper supply of water at the cheapest rate.

### Works *in the* Western District.

The Water Company's Works being confessedly insufficient for the supply of the district, and the Local Board of Health having entered into an agreement to purchase the property and privileges of that concern, I commenced by attempting to find some arrangement, which, by combining the existing with additional works, would afford a sufficient supply; and the following is the course of my researches and the conclusions arrived at, that is, with regard to the most feasible scheme, or rather the only one which would bear close investigation; for it would be alike tiresome and useless to recapitulate all the combinations which have suggested themselves, but which would not bear the test of calculation.

*Quantity.*—In the absence of more specific information, as to the quantity of water yielded by any given district, the most natural method is to measure the drainage area, and the rainfall being known, the available quantity per annum may be estimated. This gives a very near approximation, in a country where the watershed is well defined, and the subsoil impervious; but, in the present instance, not only is it difficult to define the area, but the ground is in many places covered with large masses of gravel, which absorb the water, and distribute it in such a manner, as to render it partly unavailable for collection.

Another difficulty consists in the great variation of the slope of the ground; for, whilst it is evident that a very large proportion of the rain falling upon a steep declivity would flow off the surface, it is equally clear that but a small quantity would be obtainable from flat land; and therefore the calculation for the more mountainous portions of the district would not be applicable to the low lands. Again, we have to consider the great variation in rainfall which takes place at different elevations, and also that it is affected by the aspect, in reference to the prevailing winds.

It would, perhaps, have been sufficient to have referred to Mr. Miller's observations, for proof of the fact that, *ceteris paribus*, the fall of rain increases as we ascend up to an elevation of about 2,000 feet above the mean level of the sea; but, fortunately, I am in a position to do more; for, having established accurate guages in the Cwmgelly district, I find that the rainfall very considerably exceeds that at Swansea, the elevation of the former being from 250 to 350 feet above the latter. Besides this, we must consider the character, as well as the absolute quantity, for, if the rain descend in continuous and heavy showers, a larger proportion will be collected than if it fall more frequently and more gradually. There are several minor, though not unimportant disturbing causes, such as the state of the land, whether in cultivation or not, whether drained or not,—conditions of surface, which, combined with the slope, determine in a great measure the loss due to evaporation, and the quantity absorbed by vegetation. But I have said enough to show that, in the present instance, dependence could not be placed on the absolute results obtained from calculation based upon the drainage area and the rainfall, so far as known. Whilst, however, accuracy is not to be reckoned upon, the calculations referred to are useful as a check upon other modes of computing the quantity of water available; and, with this view, I have appended, as nearly as they could be ascertained, the particulars which appear to indicate that the western district might yield the quantity required, although there is no certainty that it would do so.

Assuming, then, for argument's sake, that the yearly quantity of water required for the supply of Swansea might be obtained from the western district *in each year*, the next question arising is, in what quantities would it be available, per season, month, and day? for it is obviously only a part of the enquiry to find that the total yielded in twelve months is equal to the total requirements during that time, as is proved by the consideration, that during one period of three months double the necessary quantity might fall, whereas in the next three months only one quarter of that quantity might be obtainable. This brings us to the question of reservoir space, or the storage capacity necessary to compensate for the inequalities of the rainfall, or rather of the discharge of the brooks; and, as it is a point of primary importance, I shall submit several computations, to enable you to judge of the accuracy of my conclusions.

First, we have the statement of the Manager of the Waterworks, to be found in Mr. Clarke's Report, that during the dry months of August, September, and October, the total quantity of water flowing into the Bryn Mill reservoir was, on an average, 170 gallons per minute. This is equal to 244,800 gallons per diem, or

22½ millions of gallons in three months; then as 1,210,000 gallons per diem* is the quantity required, amounting to 111½ millions of gallons in the same period of three months, we have a deficiency of 89 millions of gallons; or, in other words, if the town were fully supplied during 18 days it would be entirely without water for 74 days.

From the above conclusion, it follows, that to ensure a regular supply, a reservoir or reservoirs must be provided, sufficient to contain at least the quantity (89 millions of gallons) shown above to be deficient; so that, assuming these reservoirs to be full when the dry season commenced, they would sustain the supply till the brooks had again risen.

Now the important point is, to determine if the figures given by the Manager of the Waterworks would be correct, not for an average, but for a minimum year; or, in other words, to ascertain what quantity could be safely calculated upon during the driest season.

The sources of supply in the western district, the waters from which do flow, or could be made to flow, into the Bryn Mill reservoir, I take as follows:—

Bryn stream;
Cocket stream;
Springs rising in Mr. Vivian's land;
Mrs. Tenant's well;
Parkwern brook;
Cwmdonkin brook; and
A small well.

* It will be remembered that the mean quantity per day, for the prospective population, was 1,100,000 gallons, and, as the demand varies, approaching a maximum in the month of July, and a minimum in February, I allow for a variation of ten per cent. above, and ten per cent. below, the mean; hence the figures in the text represent the maximum during warm months.

On the 17th of April last, these streams yielded about 460,000 gallons, and, as it may be urged that, the previous weather being dry, this quantity would represent the minimum flow, I would call attention to the following considerations.

This water is chiefly from springs, and not from surface drainage. Now springs are affected by dry weather, but not in the same manner as streams deriving their volume directly from the surface. For example, in a chalk district floods are of rare occurrence;* for the water as it falls, descends into the strata by percolation, and instead of suddenly flowing off the surface, it is given out by the springs gradually,—the strata, in fact, constituting a reservoir to a certain extent; and it is upon the knowledge of this truth that the custom of the paper manufacturers, on the Colne and elsewhere, is founded, of calculating the water which will be available at certain periods, from the rainfall during the previous season, and so accepting orders for their produce in proportion to the fall of rain during the preceding months, which regulates their power of production. In a sandstone district, it is to a certain extent the same, as I have reason to know, having been engineer to works where the whole supply for a population of about 350,000 inhabitants was derived from that rock.

These facts demonstrate, that, whilst in the case of streams fed from steep surface drainage, only a very limited period of dry weather is requisite to reduce them

* Dr. Buckland gives an ingenious proof that no flood could have occurred in a chalk district which he examined; for he observed that the bridges, though frail, and affording but a limited area of water-way, had stood uninjured for a great many years.

to their minimum flow, it takes a long continuance of drought, however intense, to affect the discharge of springs; and there is another point of importance to be kept in mind, namely, that just in proportion to the time which may elapse from the period when the dry season commences, until the brooks reach their minimum discharge, will be the time which must intervene before they rise again from that minimum.

That the quantity flowing into the Bryn Mill reservoir at the date mentioned was not the minimum, we have ample proof in the following facts:—1st. This quantity was then continuing to decrease day by day, and had diminished 50 per cent. within 17 days;—2nd. We have evidence that the Cocket stream has been dry for several weeks at a stretch, and the Bryn stream nearly so; whereas, at the period referred to, they yielded 50,000 gallons per day;—3rd. The quantity supplied to the town from this reservoir cannot be estimated at more than 100,000 gallons per diem, and we have it on record that that quantity could not be sustained.

To return to the general question; it thus appears that there are cases in which water-bearing strata may be viewed in the light of a sufficient reservoir, on account of their power of storing from a wet season to a dry one, and so compensating for the inequalities of the rainfall; but such cases are those only in which the demand does not exceed the minimum supply. For, suppose that in the middle of a dry season a heavy fall of rain should occur, then it is stored in the ground, no doubt, but only to be given out gradually as springs, and not immediately, although it may be urgently required, and probably a large portion only after the succeeding wet weather has set in; whereas, had the same rain fallen on a steep or flood district, and been allowed to flow into reservoirs, the whole quantity collected would have been available during the dry season when it was wanted.*

In a word, with springs, the water is stored in the ground, as it may be in the case of a flood district, in a reservoir, the only difference being, that in the former you cannot get at it to make use of it, and in the latter the whole is available at once; and, I argue, it matters little that you know the water is in existence, if you are prevented from employing it to supply the town.

In applying the foregoing reasoning to the western district, this additional consideration should be taken into account, viz.:—a great part of the country being flat, the rain will be retained for a longer period in contact with the surface, thereby promoting evaporation, and absorption by vegetation.

Let us now employ figures, and see the results. 1st. It appears, that even assuming the before mentioned flow of the brooks and springs, viz., that on the 17th of April, to be the minimum for three months, either a reservoir to hold 69½ millions of gallons must be provided, or the town would be without water for 57 days during a dry year. But this was not a minimum flow, nor has this been the minimum season; for, as regards the latter, taking the fall in each case from the Swansea guage kept by Mr. Jenkins, I find, that during the six months prior to the 1st of April in each year, and on an average of ten years, there fell 20·104 inches; whereas, during the six

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* The diagram in the Appendix shows this so clearly as not to require farther illustration.

months prior to the 1st of August, there fell 14·764, inches, showing a difference of 5·34 inches, or 36 per cent. on the smaller quantity; and, applying the same calculation to the three months prior to the 1st of April, we get 9·044 inches, and for the three months prior to the 1st of August, 7·044 inches, showing a difference of 2·00, or 28 per cent. So much for the difference of seasons in average years; but, as before explained, it is imprudent to calculate on average years, the only safe method being to take a minimum; and, calculating from 1850, I find that in the three months prior to the 1st of April, there fell 5·22 inches, whereas, during the same period this year, there fell 9·62 inches, the difference being 4·4 inches, or 84 per cent. in excess, showing clearly that the April guagings do not represent a minimum. But more: if in place of assuming the three months in 1850, we take the same length of time prior to the 1st of August, 1844, in which the fall of rain was only 3·14 inches, we have a difference of 6·48 inches in favour of the present year. And again: in these three months of 1844, the largest fall of rain at any one time was during two days, 0·87, and at another period, 0·9, then 0·79, then 0·39, and 0·23 inches, all the other descents being under 0·1; and considering the difference of season, the great heat, the dryness of the ground in each case when the rain fell, and the loss due to evaporation and absorption, it would be fair to estimate that not above one-half of the total fall could be collected.

As a proof of this, I would instance an occasion in which 0·36 inches of rain fell, and, from the time that the brooks in the Cwmgelly district, where the surface is much more precipitous, began to rise, until they regained their original volume, there flowed down 580,000 gallons. Now, deducting from this 400,000 gallons, the quantity which would have passed down had no change occurred in the brooks, we have 180,000 gallons as the amount of the increase, thus showing that nearly the whole of this fall of rain was absorbed.

Let us see, now, what the minimum quantity would be in such a year as 1844. On the 1st of April the guagings gave 700,000 gallons; then, assuming no difference in the season, but calculating according to the fall of rain in the previous three months, we have as 9·62 : 700,000 : : 3·14 : 228,482 gallons. Next, taking into account the difference in season, and allowing that only one-half of the rain which fell reached the reservoir, we obtain 114,241 gallons per diem. Therefore, according to this, there would be required storage for 101 millions of gallons, or, if no storage were provided, the town would be left 83½ days without water. Thus, it would appear, that deducting the capacity of the existing reservoir, viz., 8 millions of gallons, further reservoir space would be required for 93 millions of gallons.

Although not affecting the questions of minimum quantity and storage to an extent above 20,000 gallons per day, still, as a service reservoir is required at the south end of the town, and therefore the expense would be trifling, I propose to take advantage of the Fynone and Mount Pleasant brooks, say 54 million gallons per annum; and, in addition, I calculate that a supply for 100 houses may be obtained from Foxhole brook, and for 200 houses from Pen-y-filia brooks, without extended storage space, which would add to the estimates.

Having arrived at these conclusions, my next duty was to find the best site for a reservoir of such magnitude; and after an examination of the locality, I am of opinion, that the most suitable, if not the only, site, is to be found in the immediate neighbourhood of the existing reservoir at Bryn Mill.

In support of this decision, it will perhaps be enough to mention one reason out of many, namely, that there is no other spot where a reservoir of the necessary dimensions could be formed for the same outlay, and into which the various springs and brooks would flow; nay, even at this very low level, it is by no means certain that all the water required could be collected.

The outline of the proposed storage reservoir is marked upon the plan of the district, and it only remains for me to add, that Parliamentary powers would be required for its construction.

*Quality.*—On referring to Professor Brande's Report, it will be observed, that the result of the analysis of the water taken from the Bryn Mill reservoir is rather favourable, whilst that of the Cwmdonkin stream is the reverse. With respect to the latter, extreme hardness is its chief characteristic, unassociated with the advantages to be found in some of the other sources.

But I would here call attention to an important point, viz.:—the circumstances under which these samples were taken, being after a continuance of dry weather, and, in the case of the first, not from the streams, but from the reservoir near the draught pipe, so that this water had all the advantages due to admixture and long settlement, and cannot, therefore, be considered a fair sample of that yielded by the district, or of what it would be, if the whole quantity were stored. Moreover, I may state, that there having been a surplus during the previous months, it was unnecessary to admit any of the first flood waters into the reservoir, whereby much impurity was avoided: and it will be remembered, that two of the brooks flow through a populous and partly cultivated region, from which foul matter is discharged into the bed of the streams, to be flushed down into the reservoir during floods, unless the latter be allowed to pass. I find that in the village of Sketty, and along the course of the brooks, there are 101 houses draining into them, indirectly, and 46 houses directly, besides gardens, &c.; and the deterioration of the water is so evident to the senses as not to require the refinements of chemical analysis to prove that it is unfit for human use. It would not, however, be advisable to make a rule of always allowing flood waters to pass, for not only are they in some respects the most desirable, being the softest, and after settlement frequently the most pure, but they constitute the bulk of the whole quantity, and it is therefore essential that they should be stored. Besides, settlement in large reservoirs would materially improve the quality of these waters, by allowing time for the deposition of matter held in mechanical suspension; although, in the present instance, and having regard to the fact that they are also contaminated by sewage, I consider that filtration would likewise be necessary, and I have therefore included the cost of filters in my estimates for the Western works.

*Nature of the Supply.*—As the greatest proportion of the waters in the western district can be collected only at a low level, and as many parts of the town to be supplied are situated much above this point, it follows, that some means must be adopted for raising the water, so as to obtain the necessary pressure, and I propose that this object should be effected by steam power. There are, it is true, some sources from which a small quantity of water could be obtained at a considerable elevation, viz., the Cwmdonkin, Fynone, and Mount Pleasant streams; but I think enough has been said already to show that these should not interfere with the question at present under discussion, for it is certain, that the great bulk of the water must be raised artificially, as will be apparent on consulting the block plans of the town, where the elevations of the several parts are represented by different colours. The next consideration will, therefore, be the position of the pumping station; and as the Company are precluded from erecting works within three-quarters of a mile of the Singleton estate, and as it would be injurious to that fine property to do so, even if Parliamentary powers were obtained, I propose to fix the pumping station on a vacant space below St. Helen's Road, rather less than one mile from the Bryn Mill reservoir.

To this station the water could be conveyed from the reservoir by a cast-iron main-pipe, and delivered first into the filters, from which it would pass to a tank, and thence would be pumped by the engines into a main passing through the town, and communicating with the service reservoirs. In my estimates for this work, I have assumed that duplicate engines and pumps would be erected, as it is essential to provide against accidents, to which all machinery is liable, and to prevent interruption in the supply; but, in order to reduce the expense, I have also assumed that the engine power would be exerted over a period of 24 hours per diem; in fact, that the engines would work day and night, this being, according to my experience, much the cheapest mode of raising water.

With such an arrangement, the cost and the power required will be readily found as follows:—The total annual consumption of water would be 401½ millions of gallons; and, deducting the average yield from Fynone and Mount Pleasant brooks, which would be obtainable at a high level without expensive arrangements, viz., 54 millions of gallons, and the supply of houses in Pen-y-filia district, from the springs of that name, amounting to 8 millions of gallons, and also the supply from Foxhole brook at a high elevation, 4 millions of gallons, we have $54+8+4=66$ millions of gallons. This, subtracted from the total, leaves 335½ millions of gallons to be raised by the engines during an average year, to a mean height of 170 feet; and these figures are the basis for calculating the annual working expenses. But, to find the power of the engines, we must take, not the average, but the driest day of a minimum season, in which almost nothing would flow from the high sources named, and yet the demand for water might be ten per cent. above the average, or 1,210,000 gallons per day; and, assuming a pair of engines to be provided, each of them capable of raising the quantity to the elevation stated, in 24 hours, and making the usual allowances for loss and resistance, I calculate that the collective power would be about 120 horse. In order to reduce the annual working expenses, I have assumed that single acting engines would be employed, and, as the cost of machinery varies in different parts of the country, I have framed my estimates upon a tender received from an eminent firm in South Wales. Should it be enquired, "What occasion is there to raise the water to such an elevation as 170 feet?" the answer will be found in the fact, that the dimensions of the distributing pipes diminish as the pressure increases; or, in other words, (as already shown,) high pressure allows of smaller pipes being employed, which of course reduces the cost.

I have said that service tanks or reservoirs will be required, and for several reasons. 1st. Because, to sustain continuous supply in a locality where the variation in level is great, it is necessary to have mains fed from different sources, otherwise the houses in the high district would obtain no water whilst those below were drawing; or, if they did, it could only be by placing an excessive pressure on the lower parts of the town. 2nd. The system of service reservoirs supplying separate divisions presents great facilities for repairs, for, *at the worst*, it is only requisite to shut off the district, and not the whole town, and this is more important with constant than with intermittent service. 3rd. If service reservoirs be provided any given supply may be afforded with smaller mains than would otherwise be requisite. For example: —I have proposed that the engines should work 24 hours per day, not only because it would be a cheaper system, so far as the pumping machinery is concerned, but likewise because it would reduce the cost of the leading mains, by allowing 24 hours for passing the daily supply. But this can be the arrangement only when reservoirs are provided in the town, to store the water which is pumped through the mains during the night, to be distributed through the service pipes in day time; for the great bulk of the water will be consumed in six or eight hours, whilst the proposed system allows 24 hours for that water to pass through the leading mains.

One other point in connection with service reservoirs deserves notice; namely, they relieve the pipeage from that which is often an excessive and injurious strain, for the action of the engines being regular, and the draught of water by the inhabitants continually varying, the pressure in the pipes must of course be occasionally very great, unless some vent be provided for the accumulation; and this is the strongest argument against the absurd system of pumping directly into the mains, without a reservoir in connection with them.

*Price.*—Under this head, and as the price must of course be regulated by the cost, I have only to refer to the estimates and statements, which will be found in the Appendix, Nos. VIII. to XIV. inclusive. And I may mention, that in these a large margin has been left, for reasons to which I need not here advert.

In conclusion, it will be evident, from the tenor of the preceding remarks, that the chief difficulty in supplying from the western district, consists in the low level at which the water can be collected.

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## *The* CWMGELLY WORKS, *as* PROPOSED *to be constructed by the* BOARD, *under the powers of the* BILL *now pending in* PARLIAMENT.

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HAVING shewn the result of my attempt to combine the existing works with certain new sources, it now only remains, that I should describe the Cwmgelly Works, as originally designed by me, and submit the proof that they would be sufficient to afford a proper supply to the district, independently of any combination with others.

*Quantity.*—As before, I shall commence with the question of quantity, which, in this case, would be more readily determined, even in the absence of information in my possession, for the watershed is naturally better defined, the surface more precipitous, and I have not discovered any of the masses of gravel mentioned as overlying the western district; nor indeed would their existence be of so much importance, for the rain flows at once down to the bottom of the valley.

It would therefore appear, that the quantity of water available in this case might be calculated from the rain-fall and drainage area; but, as such computations are not safely made, except by those to whom the subject has long been one of anxious study, and who are in possession of a great amount of collateral information, I have not thought it necessary to trouble the Board with them upon this occasion, more especially as the brook guagings are given in detail. (*See* Appendix, No. XVI.)

Having, in the last Section, dwelt rather fully upon the general principles which affect this branch of our subject, I shall at present confine myself to a brief recapitulation of the more important and distinctive peculiarities of the Cwmgelly district. First, then, I would call attention to the elevation of the ground, and to the aspect of the valley, which debouches towards the south-west by south, a direction which must be considered most favourable for the deposition of rain, seeing that the great mass of the clouds drift inland from the south-west, surcharged with moisture imbibed during their passage over the Atlantic.

Secondly.—I do not anticipate there can be so much loss from evaporation in the eastern district, as compared with the western, from the superior slope or steepness of the surface, and the same remark applies to absorption by vegetation.

Thirdly.—The important question previously discussed, respecting the character of the rainfall, does not apply to the Cwmgelly valley so rigidly as to the western district, the former being more mountainous.

Bearing these facts in mind, I will now proceed to show that the Cwmgelly works will yield the quantity of water required—a conclusion which I am in a position to place beyond doubt, having had the brooks accurately and regularly guaged for some months past. The series of observations made on the discharge will be found tabulated in the Appendix, No. XVI., and I now proceed to state the general results.

During the months of February, March, and April, 1852, the various sources included yielded 57½ millions of gallons of water; and by the Swansea rain guage, kept by Mr. Jenkins, (Appendix, No. III.,) it appears, that during the same months, there fell 4·79 inches of rain. Further, the average fall of rain per annum, taken over nine years, was, according to the same guage, 35·53 inches. Then, if 4·79 inches gave 57½ millions of gallons, 35·53 inches would yield 427 millions of gallons; and, as the quantity required for the prospective population would be 401½ millions per annum, it follows, that in an average year, there would be a surplus quantity equal to 25½ millions of gallons. Now, let us take a minimum year, 1844, during which the rainfall, by the Swansea guage, was only 29·75 inches. Then, if 4·79 inches of rain gave 57½ millions of gallons, 29·75 inches would yield 358 millions of gallons, or 43½ millions less than the quantity required. But, as the year 1842 showed a large surplus, the year succeeding it (1843) only a deficiency of 5 millions of gallons, and the year 1845, being that which follows the minimum taken, also shows a large surplus, and as the storage space in the reservoirs would amount to 100 millions of gallons, if these reservoirs were only half-full at the commencement of the dry year, the supply would be fully sustained; and, as they would have contained 95 millions of gallons at the period named, it follows, that there would have been a surplus of 51½ millions of gallons during the driest year out of nine.

Having thus shown that the quantity of water can be obtained during even a minimum year, we have now to consider what storage space will be required to equalize the great variations in the rainfall during certain seasons, and I will apply the most severe test imaginable—much more rigid, be it observed, than that to which the western district was subjected.

Taking the driest period during ten years, from the 18th March to the 19th June, 1844, inclusive, being 94 consecutive days, there fell 1·9 inches of rain, according to the Swansea gauge; and, assuming that only one-half of this would be available, we have 15,660,000 gallons, or 13½ days' supply for the prospective population, allowing 5 per cent. above the mean demand; and this would require storage space equal to 93 millions, or 80½ days' supply. Beyond this it seems to me impossible to go; and whilst I congratulate the Board upon the result, these computations may be taken as an earnest of my desire rather to suggest difficulties connected with my own design than to hide them.

Having determined the capacity of the reservoirs, I shall now state the chief considerations which induced me to select the Cwmgelly valley, in preference to any other site. These were,—First, the existence of the brooks flowing through it; Secondly, Because the elevation was ample; Thirdly, Because the land was not of a valuable character; Fourthly, Because the water would be of sufficient depth; and, Lastly, Because, as the embankments could be constructed at a very moderate cost, the storage space would be cheaply obtained. And I feel certain that there is no situation, within the same distance of Swansea, which possesses these advantages to a degree at all comparable with Cwmgelly.

I do not consider it any part of my present task to enter into details respecting the formation of these reservoirs; but there is one point upon which the Board will probably wish to be informed, and that is, the manner in which these reservoirs would operate to store the surplus waters from all, even the most distant, sources. This would be effected as follows:—In the case of the waters from Pen-y-filia, they may either be conveyed to the town, or directed into the reservoirs; for the elevation of the Pen-y-filia tank being much above the top water at Cwmgelly, and the mains from the two sources being joined, when the water in the Cwmgelly main was shut back, then the whole of that from Pen-y-filia would pass into the town; but when the demand did not equal the quantity flowing from the Pen-y-filia brooks, the Cwmgelly main would be opened, and the surplus would pass into the great reservoirs.

With regard to the Fynone, Foxhole, and Mount Pleasant brooks, the waters from them would be conveyed into the town, and the surplus, if any, after the service reservoirs were filled, would flow through the great main into the lower Cwmgelly reservoir.

Passing over minor matters connected with these arrangements, I have only to add, with respect to capacity, that, when filled, the Cwmgelly reservoirs would contain about 100 millions of gallons of water—a quantity sufficient to supply double the present population, for a period of nearly 90 days, if not a drop of rain fell.

*Quality.*—A glance at the Map will show that the drainage area of the Cwmgelly district is not populous, and therefore that no fear need be entertained of the waters being contaminated by sewage.

I do not apprehend that filters will be required for some years, as the majority of the brooks are hardly ever turbid, in the ordinary sense of the term, even during very wet weather; but in case it should be thought desirable to construct them, I have left a sufficient margin in the estimates to cover the expense. I should, however, state, that the flood waters being chemically the most pure, I propose to impound them, reserving a power to allow the first flush after dry weather to pass; and, in this case, filters would be necessary, although the great storage capacity of the reservoirs would allow ample time for settlement, and for the deposition of any earthy matter which might be in suspension.

With regard to the vapour from the copper works, respecting which so much has been said, I never felt great alarm; because, first, it is well known to consist chiefly of carbonic and sulphurous acid gases, to be to a large extent non-condensible in water, and innocuous if it were, as it would probably only combine with the earthy bases present, and so render the water a little more hard, without producing any poisonous effect. Secondly, the direction of the prevailing winds guarantees that this vapour will very seldom rest in the Cwmgelly valley, as you will find proved by observing the red lines upon the plan, which by their position indicate the direction of the wind, and by their length show the duration from each point of the compass; and these lines are not hypothetical, but calculated from actual observations, extending over a period of three years. The configuration of the surface also affects this question; for it will be observed, that the projecting spur of Morriston Hill completely shelters the site of the great reservoirs from contact with the vapours alluded to, at times when, but for this natural obstruction, it would be exposed to them. But thirdly, what more decisive proof could be desired of the fact that these vapours would not injure the water, than is to be found in the flourishing condition of the vegetation along the Cwmgelly valley? Plants have a marvellous power of assimilating gases, and are most sensitive tests of the presence of poisonous acids. Thus the entire destruction of all vegetation in the immediate vicinity of the copper works, proves the deadly power of the vapours issuing from them in respect to plants; but this is additional evidence in favour of my conclusions, for why, I ask, should the vegetation at Cwmgelly be uninjured, if not simply because the poisonous matter is never deposited in that valley?

These considerations weighed with me from the commencement of the investigation, and it is with much pleasure that I now refer to Professor Brande's most able Report for an entire confirmation of my views. As it would have been improper to have communicated to your Chemist any particulars respecting the sources of the waters sent him for analysis, until after his Report was complete, I forbore to do so; but when that document was finished, I requested Professor Brande to make a second, a special and a most rigid examination of the waters, in order to ascertain whether copper or arsenic existed in them, even in the most minute quantity; and with this result—that not the slightest trace of either has been discovered.

It will be remembered that Professor Brande's analysis shows that most of the waters are hard, indeed this is the only objection which he makes to them; but, being an important one, it is necessary that I should explain the circumstances under which the samples were taken, and the reasons which dictated such a course.

It is not difficult to guess the quality of flood waters in such a district; for although earthy matter, and, to a less extent, vegetable matter, will generally be found suspended in them, they will otherwise be pure and soft. But no mere inspection of the district is sufficient to inform one accurately respecting the chemical constituents; and, as these are important, I decided upon taking the samples at a period when, on account of long continued drought, the waters would be in the highest state of concentration. To quote only one example: the water from Cwmgelly contained 12·03 grains of sulphate of lime, and was 15 degrees of hardness, but the quantity flowing down the brook at the time when the sample was taken was only at the rate of 35,000 gallons per diem, whereas during floods we have had four millions of gallons passing down during the same time. Now assuming this last mentioned water to be much more pure, and considering the difference in quantity, it will be obvious that when these waters are mixed in the reservoirs, the proportion both of hardness and the saline contents will be very greatly reduced. It should also be noted that the period of drought alluded to had been accompanied by easterly winds, or those which carry the vapours from the copper works over the Cwmgelly and Pen-y-filia districts; and, therefore, I argue, that as regards poisonous matter derived from these vapours, as well as saline matter derived from the land or strata, the samples analyzed represent the waters from the eastern sources in their very worst state.

*Nature of the Supply.*—Upon this point few words may suffice. The supply would be constant; and as the whole of the sources included in the Cwmgelly Works are above the most elevated part of the town, there is no room to doubt that the pressure would be most ample. Indeed, this is the distinguishing feature of the scheme, as compared with the works in the western district. The top water level of the lower Cwmgelly reservoir is 210 feet above the Quay at Swansea; and these figures will, perhaps, be sufficient to convey an idea of the capabilities of the works, in the matter of pressure.

*Mains and Service Reservoirs.*—From the Cwmgelly reservoirs a large main would be laid, to convey the water to Swansea; and in the Estimates, I have assumed this pipe to be of sufficient capacity to pass the quantity of water which would be requisite for the prospective population.

The position of the service reservoirs is indicated upon the Plan, and described in the Estimates; and, having already discussed this part of the subject fully, it will be unnecessary to extend my observations here.

*Price.*—Referring to the Estimates, and having regard to the facts, that, as before mentioned, a large margin is left in the statements of Annual Expenditure, it will be found that, assuming the rents contained in the Bill now before Parliament were charged, there would be a large surplus; and from this it follows, first, that these rents might, and probably would, be reduced; and, second, that there would be no risk of the compulsory rate ever being levied. But I do not recommend that the rating powers sought in the Bill should be abandoned, because, if granted, they would enable you to borrow money at low interest, and the objections, which might be justly urged against conferring such powers upon a trading company, do not obtain in the case of a popularly elected Board.

I am gratified in being able to add that Mr. Abernethy coincides in the conclusions I have arrived at in this Report. As you are aware, he agrees with me that the Plan submitted is the best, and the Estimates most ample, and his experience as an Engineer who has constructed extensive hydraulic works in the locality renders such an opinion very valuable.

Finally, I have much pleasure in bearing testimony to the very great assistance I have received from Mr. Hall and Mr. George Abernethy, whose exertions in this case demand my best acknowledgments.

I have the honor to be,

GENTLEMEN,

Your obedient Servant,

MICHAEL SCOTT, C.E.

26, GREAT GEORGE STREET, WESTMINSTER,
*30th April*, 1852.

# STATEMENT,

*In the Matter of the* ARBITRATION *between the* SWANSEA LOCAL BOARD OF HEALTH, *and the* SWANSEA WATER-WORKS COMPANY, *respecting the* TRANSFER *of the said* WORKS.

IN the absence of information which I have failed to obtain, it is manifestly impossible for me to enter upon details respecting the condition of the existing works; and, for the same reason, I am precluded from discussing other, and not unimportant questions, relating to this enquiry. I shall therefore confine myself chiefly to the elimination of the principles involved, and the exposition of general views, in the hope of shedding some light upon the real position of the matter, and the nature of the questions pending between the Local Board of Health and the Company, but, at the same time, not withholding any suggestions which may arise bearing upon the subject, and which ought to be submitted to the arbitrator for consideration.

At one of the earliest meetings of the Water Committee of the Local Board of Health, which I had the honor to attend, I recommended that in any arrangements which might be in contemplation, the existing Water Company should be dealt with, not only on fair, but on liberal terms; and it is with pleasure I bear testimony to the fact that that recommendation coincided with the views of the Committee. I hold the same opinions still, and entirely repudiate the idea, which some entertain, that any water company's works should be purchased compulsorily at their value to the purchaser, without regard to their cost and to the benefits previously derived from them. For instance, in valuing water mains, I do not think it would be just to leave out of view the superior cost of pipes some years ago, although they could now be obtained at a much reduced price, arising from improvements in the manufacture; because this additional expenditure was no fault of the Company, if no pipes of equal quality could be got for less money at the date when they were required.

Guided by these principles, I proceed with the investigation, and commence by enquiring what is the position of the Company?

The Swansea Waterworks Company is incorporated under an Act of Parliament passed in the year 1837, and I find that the preamble recites, that—"Whereas the inhabitants of the town and borough of Swansea, in the parish of Swansea, in the county of Glamorgan, and the shipping frequenting the port thereof, are not at present well and conveniently supplied with water, and it would greatly contribute to the health, comfort, and convenience of the said inhabitants, and lessen the danger to lives and property in cases of accidents by fire, if a more wholesome and abundant supply of water were provided for the said town and borough: and whereas a sufficient supply of water, for the purposes aforesaid, may be obtained from divers springs and streams" (and so on describing the various streams and ponds): "and whereas the several persons, whose names are hereinafter mentioned have entered into a subscription, and agreed to raise the necessary sum, to make and maintain all the necessary works for supplying the inhabitants of the said town and borough of Swansea, and the shipping frequenting the port thereof, with good and wholesome water," &c. The Act then proceeds to give the Company power to make, maintain, and improve the works, for affording a sufficient supply of water to all the inhabitants within the limits of the Act.

Here we have a solemn compact or bargain, concluded between the Legislature and the Company, whereby, on the one side, very important powers and privileges are granted, on consideration that certain specific duties be performed by the Company. These powers, guaranteed by the whole force of law, include compulsory purchase of lands, levying rates on the inhabitants, and receiving large profits from them; and they ought to constitute a monopoly, so long as the Company's share of the compact is performed, but not necessarily for one day longer. If, then, it can be shown, that the engagements of the Company have hitherto been, and still continue to be, faithfully fulfilled, according to the agreement made with Parliament, and assuming that the stock of a water company was proved to be equal in every respect to the highest class of investments, it might be argued, that any party wishing to purchase by compulsion their works, rights, and privileges, ought to compensate the Company in full, and secure to the proprietors therein a revenue equal to that which they legitimately enjoyed, at the date of transfer; special regard being had to the facts, that the existence of the Company's monopoly did not interfere with the public good, and that the revenue derived from it did not exceed a just and fair return for the capital invested. For Parliament did not grant the peculiar powers alluded, to in order to enrich any individuals or aggregation of persons, at the expense of the community, but in order that the inhabitants of Swansea should obtain an abundant supply of good and wholesome water, as the preamble of the Act clearly proves.

Assuming, then, that these premises cannot reasonably be disputed, we have next to inquire—

First, into the character of the investment;

Second, whether the existence of the Company's monopoly interferes with the public good; and,

Third, whether the revenue derived from that monopoly is a fair and just return upon the capital invested.

First, as to the character of the investment.

The stock held in a water company evidently cannot be considered a first-class security. For example: it has a very different value from landed property, inasmuch as it possesses none of those social and political advantages conferred by the ownership of land, and so eagerly sought for in this country; nor is it comparable with it, simply viewed as a security for the principal sum, being subject to fluctuations in value, from which land is free. Water-works stock might, with more propriety, be compared with house property, although even here there is an obvious difference between the two; for, whereas the amount of profit which the latter might yield is not limited, there is a limit appointed by the legislature to the dividends of water companies; and there always has been, and must necessarily be, a practical limit, inasmuch as large profits realised by any such concern would inevitably induce competition. Once more, it may be said, that waterworks stock is most strictly comparable with that held in canals, railways, or gas works; but here again there is a difference, although perhaps not so great, in the fact, that the latter only minister to the convenience of the public, and consequently may come short of their engagements with more impunity than a water company, the proper performance of whose duty materially affects the very existence of the people.

Having thus stated that waterworks stock stands under house property in value, we may assume, that, even when the sale is compulsory, no price beyond the ordinary number of years' purchase for which house property can be obtained would be either just or fair, except in cases where the Company could prove, that peculiar circumstances had compelled them to forego a proper return upon their capital in former years; or, in other words, that the Company had expended capital in order to fulfil their their duty to the public, and upon which a fair return might be expected at a future period, but which had not proved remunerative up to the date when their works were to be transferred.

For instance, the Company may have laid mains to supply a few isolated dwellings at the further end of a new street or road, and at a period when the water rents from these houses would not yield a return of 1 per cent. on the cost of the pipeage. This may have been done chiefly for the convenience of the tenants of these dwellings, although also in anticipation of, and calculating upon, a fair return when the intermediate vacant ground should be built upon. I say, in such a case, showing a distinct anxiety on the part of a Company to consult the public good in the first place, and the interest of the proprietors in the second, and indicating a strong desire to perform that which is not less than a duty, the arbitrator would not only be entitled, but bound, to take such expenditure into consideration. I am, however, informed, that nothing of this kind has been done by the Swansea Waterworks Company; on the contrary, they have entirely neglected alike their duty and the interests of the inhabitants, for I find a very large portion of the town and borough without either pipes or water.

With regard to the second question, namely, whether the existence of the Company's monopoly interferes with the public good, I shall be brief.

I apprehend that no one will question the fact that the public good is, and ought to be, paramount to any personal considerations; and I believe few will deny that an abundant supply of pure water is essential to the health and welfare of an urban population. Now, as the Company has only given a supply, intermittent in character, deficient in quantity, and indifferent in quality, to a small part of the population within tne limits of the Act, and has afforded no supply whatever to the larger portion of the borough, it necessarily follows that the public good has already been, and is now being, sacrificed; and, as I shall hereafter prove that the Company have not the means of giving a proper supply to the district from the sources at their command, it results, that the existence of the monopoly enjoyed by the Company is incompatible with the public good.

With regard to the next point, namely, whether or not the revenue is a fair return for the capital employed, we have first to determine the amount of capital; and second, the amount of clear revenue. The capital is fixed by Act of Parliament, and therefore cannot be legally increased; because the legislature, in effect, very properly says, that an extension of capital being almost tantamount to the creation of a new concern, every such arrangement must be submitted to us in our judicial capacity before we authorize it in our legislative capacity. Now, assuming that the borrowing powers contained in the Company's Act have been exerted to the utmost, the total capital cannot exceed £15,000. By another clause in the Act, I find that the Company is precluded from holding any surplus lands; and, taking the description of the works from Mr. Clarke's Report, who obtained his information, according to the said Report, from the Manager, and making due allowance for the superior cost of pipes, &c., at the time when the works were executed, as compared with the present, I estimate the cost to the Company at the sum of £8,000; and, adding to this parliamentary expenses, compensations, law and incidental charges, which I assume at £3,000, we have a total of £11,000.

It would therefore appear, that the Parliamentary capital was not exceeded, and that it would be most liberal to estimate the sum upon which a return was due at £15,000.

With regard to the revenue of the Company, I have no certain information; but assuming the sum collected at £1,600, then we have to deduct working expenses, repairs, and charges, which cannot amount to less than

£500, leaving £1,100 per annum as clear income, or $7\frac{1}{3}$ per cent. on a capital of £15,000.

One thing seems clear from the foregoing, that the Company cannot urge the non-success of the undertaking, as a remunerative investment, as a reason for not extending the works to meet the growing wants of an increasing population; for, surely $7\frac{1}{3}$ per cent. must be considered a good return, when money can be borrowed at 4 per cent.; and additional proof of the soundness of this conclusion may be seen in the Company's proposal to reduce their charges rather than permit the transfer of their Works to the Local Board of Health. In fact, it would appear from statements made by the Manager, that, in his opinion, a very small additional outlay would have provided an ample supply for the whole of the town.

Such are the more prominent features of the case; and, having discussed the position of the Company generally, I propose now to consider in detail, in what particulars, and to what extent, they have failed to fulfil their engagements, and to see how far these differences affect the question of value; and I shall divide my observations under the heads of—The extent of the supply—The nature of the supply—The quantity of the supply, and—The quality of the supply.

First, as to the extent of the supply. When application was made to Parliament for an Act, it was urged by the promoters, that the Borough of Swansea was very badly supplied with water, and that they were able and willing to provide a good supply, the words of their declaration being "abundant and wholesome." On the faith of these representations, ample powers were obtained; but what has the Company done? Selected a portion of the borough which, from the density of the population and the very low level, could be served at a minimum cost, leaving the more elevated and more thinly inhabited parts without any supply whatever, from the Waterworks; no doubt because they were more expensive and more difficult to deal with. And not only this, but when the experience of fifteen years had proved either the unwillingness or incompetency of the Company to supply the district alluded to, and when the Local Board of Health proposed to take measures to remedy the evil, the Company opposed their proceedings, although, at the same time the Manager admitted, and sought to prove, that "the Town of Swansea, and the neighbourhood thereof respectively, are not at present sufficiently supplied with water!"* If further proof be wanted of this fact, it may be discovered in the number of houses served by the Company (1,102) as compared with the total number, or 5,452; leaving 4,350 houses unsupplied. These figures speak for themselves; and though, no doubt, the difference is increased by the number of those who have not availed themselves of the supply they might have obtained, they place the Company's neglect in a strong light, especially when viewed in connection with the fact that the necessary capital for extensions could readily be obtained, as the Company prove, by admitting that the whole town could be served at rates of charge not much above two-thirds of those at present levied, and probably required, for the existing limited supply.

I grant that the works present few or no facilities for extension, and that new sources would have to be

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* The preamble of a Bill promoted by that gentleman, but thrown out.

selected ; but this is no excuse, inasmuch as there appears no reason to doubt that if the Company proved the rates specified in the proposal made to the Water Committee, Parliament would have granted powers to remedy an evil of such magnitude.

With respect to the nature of the supply, there can hardly be two opinions, for it is exceedingly defective, being not only intermittent, but miserably insufficient in pressure. It would not be difficult to show, that many houses are frequently without water, and the pressure being so limited, it is obvious that there can be no proper supply to the upper floors of the houses, even in the most depressed parts of the town. Upon this point we have the evidence of the turncock attached to the Works, who stated that the water is cut off from the lower parts at eleven o'clock A.M., and restored between four and five o'clock P.M. ; and, with regard to the head pressure obtainable from the reservoir, the same man declares that when the water is cut off from the lower part, it takes two hours before its appearance under pressure in the upper part, so that the supply, properly speaking, is not got till one o'clock ; but, he adds, that when turned on again to the lower part of the town, the water runs down the hill in one hour.

These statements sufficiently indicate the impossibility of serving the upper portion of the town from the present works, and I find that the Company are precluded, by Act of Parliament, from erecting machinery within three-quarters of a mile of the reservoir.

The next point is the quantity supplied: and the facts, of the service being intermittent, and pressure most deficient, prove at least that the water is not obtainable at all times, nor in desirable quantity; but we must take a wider view. The Company's engagement was to supply the *borough;* and, I submit, this they cannot do in a sufficient manner, without the construction of additional and extensive works, because the necessary quantity is not available from those at present existing.

Not to enter upon more formal proofs at present, I shall assume the figures furnished by the Manager of the Waterworks, and to be found in Mr. Clarke's Report, which give the supply available from the Bryn Mill Reservoir, at 170 gallons per minute, in the dry months of August, September, and October; whereas the minimum supply, required for the borough, is about 425 gallons per minute, leaving a deficiency of 367,000 gallons per diem.

The third question is quality; and I would, on the threshold observe, that it is, to a great extent, a relative and not an absolute one. For instance, I do not think that a Water Company is bound to supply only such water as is absolutely pure, although I do maintain, that all companies are bound to supply the best water which they can obtain in the district, and at reasonable cost; and, assuming that such water is defective in point of purity, softness, or other requisite quality, and that known practicable means exist whereby it could be much improved, I further maintain that the Company is bound to use such means, and endeavour to increase the salubrity of the supply. Now what is the quality of the water supplied by the Swansea Waterworks, and what exertions has that company made, to ensure the highest obtainable purity? I shall very shortly be in possession of an authoritative decision upon the first point; but, meantime, I would call attention to the fact, that much of the drainage from the district of Sketty flows into the streams supplying the Bryn Mill Reservoir, and contaminates the water.

I am aware that there is a clause in the Act which gives power to inflict a penalty upon any person who fouls the water; but the very existence of this clause is condemnatory of the Company, because, whilst it shows the importance attached to purity by Parliament, it at the same time leaves no excuse for the neglect.

The Company, I am informed, have not proceeded for penalties against any one, probably influenced by the consideration that other drains must be provided before the penalty could be recovered, the streams being the natural channels and outlets for the sewage of the district.

But more; not only is the water defiled by house sewage, but also by drainage from highly manured and cultivated lands and gardens, so that, during rainy weather, it is very muddy and impure. If it be replied, that, when the water is in the condition described, it is not admitted into the reservoir, but turned aside and permitted to run to waste, I answer that I have seen it, and others have seen it: and, if the occasions I can prove are rare exceptions, then it must follow, that a large proportion of the whole water, so far as quantity is concerned, is run to waste, and consequently not available for the supply of the town, under the system pursued by the Company. And, to afford some idea of the relative quantities flowing down some brooks in this district, during a given time, at periods when the water is discoloured, as compared with the quantities when it is clear, I will give an instance, obtained from several months' guagings, and in which the proportion was as five to one, for water discoloured, compared to water clear.

But, it may be contended, that the inhabitants have not complained of impurity; and admitting, for argument's sake, that no complaints have been made, still it is a bad position, for the question is not "Do the people complain?" but "Is the water the best, and in the best condition to be obtained in the district at a moderate cost?" Moreover, there is another point to be noticed in connection with this branch of our subject, namely, that a considerable proportion of the whole quantity of water flowing into the Bryn Mill Reservoir is comparatively pure, and tends to dilute the impure water; but a great part of the good water flows from springs within the Singleton Estate, and is the property of Mr. Vivian, the Company being expressly prevented, by their Act of Parliament, from taking this water without Mr. Vivian's consent. Now I do not assert, that such consent would be refused were it necessary for the public good; but in valuing the Swansea Waterworks, no credit should be given for that which, although in the Company's use, is the property of another party. Even if it could be proved, what I am far from admitting, that it was essential to employ impure water, I contend that the Company were bound to construct reservoirs of sufficient capacity to allow the foreign matter to deposit, and also filters for the purification of the water; but not only has no such provision been made, but, by a clause in the Act, the Company are precluded from making any such works, within three-quarters of a mile of the reservoir.

One word as to the supply provided for the extinction of fire; there being no pipes, and of course, no water, in a large part of the town, I cannot see how this has been effected.

Before closing this imperfect statement, and although I am not in possession of much necessary information respecting the Company's accounts, I think it my duty to submit some observations regarding the revenue, which will no doubt be an element in the calculation of value by the Arbitrator; and to commence with the income:— It is sufficiently apparent, that, to be legitimate, the income must be derived from the sources, in the proportions, and under the restrictions authorized and contained in the Company's Act, and it will therefore be important for the Arbitrator to be assured of the following —1st. That the whole of the income has been derived from, and in return for, *a supply of water;* 2nd. That in no case has the charge for water exceeded the limits mentioned in the Company's Act, and that no larger sum be taken as income for any year or years than was earned in those years; 3rd. That all the matters which the Company covenanted with Parliament to perform have been done. If the Company had fulfilled these conditions, then the amount received would have been legitimate income; but, having failed to do so in several important particulars, it follows, that a very considerable deduction ought to be made from the receipts; such an amount, in fact, as would pay interest upon the capital which must be expended to enable the Company to fulfil the engagements named, not to mention increased working expenses. Such deductions being made, the next consideration is the cost of renewals, maintenance, and current working expenses.

With respect to the two former, the only fair mode of calculation is, to allow an annual sum sufficient to maintain the plant for ever in good working condition; for it is evident that if the plant fall into decay and get worn out, the income would cease, and that cannot be considered clear revenue which does not allow first for necessary renewals. I would impress this the more upon the Arbitrator, because I am informed that it is stated by the Company that hitherto but little money has been expended on renewals, or repairs; for just in proportion to the smallness of the amount which has heretofore been devoted to this object will be the magnitude of the sum which will hereafter be required.

No part of waterworks is everlasting; pipes, for example, have a certain life; and if, in the case of the Swansea Works, that period has not yet arrived when repairs begin, on account of their yet limited and equal age, it is certain that when they do commence to fail, the failure will be all but universal, and, should no provision have been previously made, the whole income will be absorbed for several years. In a word, the decay being certain, it must be met, either by one large outlay, or numerous small ones; and it should be borne in mind, that the imperfect nature of the supply hitherto afforded has contributed materially to keep down the expense of repairs; as, for instance, I am informed that the Reservoir at Bryn Mill, though foul, has not been cleaned for twelve years, or, in the case of the pipeage, which has never been subjected to one-half the pressure necessary to give an efficient supply, for although each pipe may have been proved separately, the *joints* never could have been tested. Now as it is not conceivable that the present state of things should continue, who can predict the result when the water enters these pipes for the first time under proper pressure?

The next point, namely, working expenses, should likewise be ascertained; and I submit that it is important to consider, not only what the works have hitherto cost under this head, but what they ought to cost. For example, it may happen, that the works have been managed by gentlemen, who, being proprietors of stock in the Company, have given their services gratuitously, but nevertheless a charge ought to be deducted from the income for management.

Then again, from the defects in the supply, fewer men are no doubt at present employed than would be required under a more perfect system; and not only is it essential to keep these matters in view, but regard should be had to the necessity for a new station, for the erection of pumping machinery, &c. &c., before the supply could be made efficient, and thus an enormously increased charge would arise for working expenses. Having had some experience in these matters, I may add, that a very usual allowance, in such cases, for working expenses, is forty per cent. of the total receipts.

Finally, a Company unable to supply one-half of the existing population, can of course have no claim on account of prospective advantages; and yet, in cases of the transfer of waterworks, in which I have been engaged, where remuneration for prospective advantages could be, and was justly demanded, and where the position of the parties, in respect of having fulfilled their engagements to the public, was such as to give them much superior claims to any that could in fairness be preferred on behalf of the Swansea Company, the awards made did not average above sixteen years' purchase, calculated on the clear revenue available for dividend, after paying all working expenses.

I am induced to quote one case, which occurred recently, and was in many respects parallel to that in question, and which I can undertake to prove before the Arbitrator. It is as follows:—Certain waterworks were sold during last month; the population of the town is about 32,000; the rental actually collected for last year, was £2,140; the working expenses were £500, leaving a surplus of £1,640. The Company demanded for their works, in the first instance, £28,000, or seventeen years' purchase, and they obtained £13,000, or eight years' purchase.

In conclusion, such is a brief exposition of the Company's case, as it appears to me, and such the considerations which ought to be weighed in connection with it, *assuming that the sale of the concern was compulsory;* and it only remains, that I should call attention to the important fact, that, in effect, it is the purchase by the Board which is compulsory, and not the sale by the Company. I apprehend that this is so obvious, as not to require illustration; for the sole object of the Board being to afford the best possible supply to the borough, at the lowest possible price, it is certainly not the interest of the Board, as representatives of the consumers of water, to purchase the works of the Company, it being perfectly clear that Swansea could be supplied at a cheaper rate from other sources. But the Company, foreseeing that the introduction of an improved supply, by a rival body, would go far to extinguish their present profits, are naturally alarmed; and, feeling their inability to compete with the proposed new works, they prefer selling the concern, the purchase of which will entail upon the ratepayers an additional outlay to produce the desired result, viz., an abundant supply of pure water.

I think the Company is perfectly justified in protecting the interests of the shareholders, who are certainly entitled to fair compensation; but it should not be forgotten that the non-fulfilment of engagements by the Company has been the origin of the present crisis.

MICHAEL SCOTT,
*Civil Engineer.*

SWANSEA, *7th April,* 1852.

## PROFESSOR BRANDE'S REPORT UPON THE SWANSEA WATERS.

Eight Samples of the above Waters were sent to me on the 8th April last, from Swansea, by Michael Scott, Esq., C.E., in eight two-gallon stone bottles, for the purpose of analysis, and with a request that I should Report upon the general characteristics of these Waters, and their suitableness, or otherwise, for culinary, detergent, and generally for domestic use and manufacturing purposes, more especially noting:—

1. The degree of hardness, according to Dr. Clarke's Test.
2. The presence, if any, of organic matter.
3. The existence of matters in mechanical suspension.
4. The proportionate quantity of saline matter in solution, with a qualitative analysis of the same.
5. The effect of the various waters upon lead.
6. Such additional observations as my experience may suggest.

The following is a List of the Samples, numbered in the order in which they were examined, together with the distinctive marks and numbers which were upon the several labels attached to them.

| | | | | |
|---|---|---|---|---|
| Sample | 1 | marked | C.G. | No. 3. |
| ,, | 2 | ,, | P. | ,, 1. |
| ,, | 3 | ,, | P. | ,, 2. |
| ,, | 4 | ,, | P. | ,, 3. |
| ,, | 5 | ,, | P. | ,, 4. |
| ,, | 6 | ,, | F. | ,, 1. |
| ,, | 7 | ,, | B.M.R. | ,, 1. |
| ,, | 8 | ,, | C.D. | ,, 1. |

PHYSICAL PROPERTIES.—All these waters were bright, tasteless, colourless, and inodorous. They were entirely, or almost entirely, free from all matters in mechanical suspension.

As far, therefore, as their general *physical* properties are concerned they are unexceptionable.

SOLID CONTENTS.—An imperial gallon of each of the samples of water was slowly evaporated. The solid residues were all of them white, or nearly so, and their respective weights were as follows :—

| Number of the Sample. | Mark of the Sample. | Grains of Solid Matter in the Imperial Gallon. | Fractional proportion in the Water by Weight. |
|---|---|---|---|
| 1 | C.G. No. 3. | 17·40 | $\frac{1}{4023}$ |
| 2 | P. No. 1. | 11·80 | $\frac{1}{5932}$ |
| 3 | P. No. 2. | 11·38 | $\frac{1}{6151}$ |
| 4 | P. No. 3. | 17·78 | $\frac{1}{3937}$ |
| 5 | P. No. 4. | 6·10 | $\frac{1}{11475}$ |
| 6 | F. No. 1. | 16·00 | $\frac{1}{4275}$ |
| 7 | B.M.R. No. 1. | 9·20 | $\frac{1}{7608}$ |
| 8 | C.D. No. 1. | 13·00 | $\frac{1}{5384}$ |

CHEMICAL CONSTITUENTS.—When heated, each of these residues, with the exception of Samples 2 and 8, P. No. 1, and C.D. No. 1, became very slightly blackened from the presence of organic matter, but they soon whitened again, and afterwards exhaled traces of nitrous acid. The presence of very small quantities of vegetable matter would account for the blackening, and the nitrous fumes indicate a small quantity of an earthy nitrate; traces of iron, in very minute quantities, were also discoverable.

By the application of the usual tests these waters were found to contain lime, soda, magnesia, sulphuric acid, chlorine, nitric acid, silica, traces of potassa, of oxide of iron, and of organic matter; but the three latter substances in proportions so small as scarcely to admit of quantitative determination in the proportion of water submitted to experiment.

The above bases and acids were separated from the waters, as sulphate of lime, (constituting in all of them the predominant ingredient,) chloride of sodium or common salt, sulphate of soda, sulphate of magnesia, and a nitrate, which was separable in one instance as nitrate of magnesia; in the others, therefore, I have considered the nitric acid as in combination with that base.

The following are the results of the quantitative analyses, from which it will be seen that the saline contents of the waters are similar in each of them, but that they are present in very different proportions. They are estimated in grains contained in the imperial gallon.

SAMPLE I.—Marked C.G. No. 3.

| | Grains. |
|---|---|
| Sulphate of Lime . . . . . | 12·03 |
| Chloride of Sodium . . . . . | 1·46 |
| Sulphate of Soda . . . . | 3·00 |
| Sulphate of Magnesia . . | |
| Nitrate of Magnesia . . . . | |
| Silica . . . . . . | 0·91 |
| Oxide of Iron . . . . . | |
| Organic matter . . . . | |
| Trace of Potassa Salt . . . . | |
| Grains in the Gallon . . . | 17·40* |

* A very slight brown deposit in this water, after evaporation.

SAMPLE II.—Marked P. No. 1.

| | Grains. |
|---|---|
| Sulphate of Lime | 7·80 |
| Chloride of Sodium | 1·80 |
| Sulphate of Soda, Sulphate of Magnesia, Nitrate of Magnesia | 1·25 |
| Silica, Oxide of Iron, Trace of Potassa Salt | 0·95 |
| Grains in the Gallon | 11·80 |

SAMPLE III.—Marked P. No. 2.

| | Grains. |
|---|---|
| Sulphate of Lime | 7·90 |
| Chloride of Sodium | 1·43 |
| Sulphate of Soda, Sulphate of Magnesia, Nitrate of Magnesia | 1·10 |
| Oxide of Iron, Silica, Trace of organic matter, Trace of a Potassa Salt | 0·95 |
| Grains in the Gallon | 11·38 |

SAMPLE IV.—Marked P. No. 3.

| | Grains. |
|---|---|
| Sulphate of Lime | 12·52 |
| Chloride of Sodium | 1·20 |
| Sulphate of Soda, Sulphate of Magnesia, Nitrate of Magnesia | 2·95 |
| Silica, Trace of Oxide of Iron, Trace of organic matter | 1·11 |
| Grains in the Gallon | 17·78 |

### SAMPLE V.—Marked P. No. 4.

| | Grains. |
|---|---|
| Sulphate of Lime | 3·72 |
| Chloride of Sodium | 0·85 |
| Sulphate of Soda<br>Sulphate of Magnesia<br>Nitrate of Magnesia | 1·11 |
| Silica<br>Trace of organic matter<br>Trace of Oxide of Iron<br>Trace of a Potassa Salt | 0.42 |
| Grains in the Gallon | 6.10 |

### SAMPLE VI.—Marked F. No. 1.

| | Grains. |
|---|---|
| Sulphate of Lime | 12·8 |
| Chloride of Sodium | 1 9 |
| Sulphate of Soda<br>Sulphate of Magnesia<br>Silica | 1·1 |
| Trace of Nitrate of Magnesia<br>Trace of organic matter<br>Trace of Oxide of Iron<br>Trace of a Salt of Potassa | 0·2 |
| Grains in the Gallon | 16·0 |

### SAMPLE VII.—Marked B.M.R. No. 1.

| | Grains. |
|---|---|
| Sulphate of Lime | 4·47 |
| Chloride of Sodium | 2·33 |
| Sulphate of Soda<br>Sulphate of Magnesia<br>Nitrate of Magnesia | 2·00 |
| Oxide of Iron<br>Organic matter<br>Salt of Potassa | 0·40 |
| Grains in the Gallon | 9·20 |

SAMPLE VIII.—Marked C.D. No. 1.

| | Grains. |
|---|---|
| Sulphate of Lime . . . . . | 10·3 |
| Chloride of Sodium . . . . | 1·8 |
| Sulphate of Soda . . . <br> Sulphate of Magnesia . . <br> Nitrate of Magnesia . . | 0·9 |
| Grains in the Gallon . . | 13·0 |

RELATIVE HARDNESS.—The following are the degrees of hardness of the samples of Swansea Water, in terms having reference to distilled water as *unity*, and also in the terms of Dr. Clarke's test; the latter, however, is not to be relied on, inasmuch as Dr. Clarke's *test solution of soap* is liable to variation. The results indicated in the first column were obtained in the usual way, with a solution of white Castile soap, in proof spirit, of such strength as that ten drops of it gave a persistent froth, with four ounces of pure distilled water.

| Nnmbers and Mark of Sample. | Hardness in reference to Distilled Water as = 1. | Hardness as determined by Clarke's Test. |
|---|---|---|
| | ° ′ | ° ′ |
| No. 1 C.G. No. 3 . . . | 15 0 | 17 1 |
| „ 2 P. „ 1 . . . | 10 0 | 11 6 |
| „ 3 P. „ 2 . . . | 9 5 | 10 8 |
| „ 4 P. „ 3 . . . | 15 0 | 17 0 |
| „ 5 P. „ 4 . . . | 5 4 | 6 6 |
| „ 6 F. „ 1 . . . | 14 0 | 16 3 |
| „ 7 B.M.R. „ 1 . . . | 8 0 | 8 7 |
| „ 8 C.D. „ 1 . . . | 14 0 | 15 5 |

EFFECT OF CONTACT WITH METALLIC LEAD.—Pieces of bright sheet lead, one inch wide and four inches long, were partly immersed in each of the waters, so as to expose the metal to the joint action of the water and air, and were examined at the end of sixty hours. All the pieces of lead were found more or less tarnished; those in Samples 3, 5, and 7, marked P. 2, P. 4, and B. M. R. No. 1, were most acted upon. In Sample 6, the bright surface of the metal was only slightly dimmed. The tarnish and deposits in all these cases may be ascribed to sulphate of lead, but in no case was any lead dissolved by any of the waters, nor was the action such as to be considered deleterious, or interfering with the conveyance of the water through leaden pipes, or its preservation in leaden cisterns.

General Remarks.—The above waters being all bright, colourless, tasteless, inodorous, and adequately aerated, are fit for many of the usual purposes to which common spring waters are applicable, but with exception of Sample 5, P. No. 4, they all come under the denomination of *hard waters*, and the Samples 1, 4, 6, and 8, marked respectively C.G. No. 3, P. No. 3, F. No. 1, and C.D. No. 1, are inconveniently hard for most culinary and domestic purposes. These qualities are evidently derived from the predominance of sulphate of lime in all the samples, amounting in some of them to upwards of twelve grains in the gallon, or more than $\frac{1}{5833}$ of the whole weight of the water, this being a salt which readily decomposes soap, and the presence of which is very effective in producing what is termed *hardness*.

These waters are also distinguished by the absence of all *carbonates*, containing no carbonate of lime held in solution by carbonic acid; consequently they are not softened by boiling, as is the case with Thames water, but are on the contrary *hardened* in direct proportion to the quantity of vapour driven off by heat. They, however, admit of being softened by the addition of carbonate of soda, the substance usually resorted to for that purpose in laundries supplied with hard water, and which is effectual and harmless when judiciously employed in quantities suited to the quantity of sulphate of lime present.

The almost entire absence of all mechanically suspended matters in these waters, may perhaps be ascribed to the circumstances under which the samples were collected, or to the long prevalence of dry weather; and it is probable that after long or heavy rains they would no longer remain perfectly bright, in which case *filtration* would, of course, be advisable; but in their present condition there seems no necessity for resorting to that process.

As far as the *quantity* of the solid contents of these samples of water is concerned, it may be said to be small in Nos. 5 and 7, marked P. No. 4, and B. M. R. No. 1; and in the others it falls short of that contained in Thames water, and in by far the greater number of the *spring waters* in common use in and about London.

WILLIAM THOMAS BRANDE.

ROYAL MINT,
*3rd May*, 1852.

Since writing the above Report, the question has been put to me, whether any of the above waters contain any traces of arsenic, or of copper? I have searched for both those metals, and find that they are perfectly free from them.

W. T. BRANDE.

*5th May*, 1852.

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KEY *to the* MARKS *on the* SAMPLES, *referred to in* PROFESSOR BRANDE'S REPORT.

No 1.—C.G. No. 3, Cwmgelly Water, below the Junction of the two Brooks.

No. 2.—P. No. 1, Pen-y-filia Brook, No. 1.

No. 3.—P. No. 2, Pen-y-filia Brook, No. 2.

No. 4.—P. No. 3, Pen-y-filia Brook, No. 3.

No. 5.—P. No. 4, Pen-y-filia Brook, No. 4.

No. 6.—F. No. 1, Fynone Brook.

No. 7.—B.M.R. No. 1, Bryn Mill Reservoir, near draught pipe.

No. 8.—C.D. No. 1, Cwm Donkin Brook.

Samples taken by JAMES HALL.

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## ADDITIONAL REPORT, BY PROFESSOR BRANDE.

SIR, ROYAL MINT, 10*th May*, 1852.

I HAVE now completed the examination of the three additional samples of the Swansea waters, sent to me by your order for analysis, and received on the 3rd inst., in three two-gallon stone bottles with sealed corks. They were marked as follows:—

Sample 1 marked "C.G. No. 3, 30th April."
" 2 " "N.F., 1st May."
" 3 " "F.H., 30th April."

PHYSICAL PROPERTIES.—The samples marked C.G. No. 3, and N.F., were tasteless, inodorous, well aerated, but not perfectly bright, in consequence of the presence of mechanically suspended matters, though in such small quantity as not to admit of being separately determined by weight in a gallon of water; they chiefly consisting of finely divided earthy matters. The sample F.H., on the contrary, was perfectly bright, tasteless, inodorous, and adequately aerated.

SOLID CONTENTS.—One imperial gallon = 70,000 grains of each of the above waters, was slowly evaporated, and the residues were in each case perfectly dried at a temperature of 212°. They then weighed as follows:—

| Sample and Mark. | Grains of Solid Matter in the Imperial Gallon. | Fractional part in the Water, by Weight. |
|---|---|---|
| 1. C.G. No. 3 | 10·00 | $\frac{1}{7000}$ |
| 2. N.F. | 7·60 | $\frac{1}{9210}$ |
| 3. F.H. | 25·94 | $\frac{1}{2698}$ |

CHEMICAL CONSTITUENTS.—When the above-mentioned residues were heated to dull redness, those from samples 1 and 2, marked C.G. No. 3, and N.F., acquired a dark brown colour, but gave off no alkaline, or acid fumes; they only yielded very minute traces of organic matter, of vegetable origin. The residue from sample 3, F.H., was not materially discoloured by heat, but gave off very slight traces of nitrous vapour, and appeared quite free from organic matter.

By means of the usual tests these waters were found to contain lime, soda, chlorine, sulphuric acid, and silica. Oxide of iron was discoverable, but in very small quantities, in samples C.G. and N.F., but there was none in F.H. The bases and acids were separated from the water in the form of sulphate of lime, chloride of sodium, and sulphate of soda. F.H. contained a nitrate, probably of magnesia, and also a small quantity of sulphate of magnesia; but I could detect no magnesian salts either in C.G. or N.F., both of which, however, gave slight indications of the presence of a salt of potash.

The following are the results of the quantitative analyses of the contents of these waters, estimated in grains, contained in one imperial gallon of each of the samples.

SAMPLE I.—Marked C.G. No. 3.

| | Grains. |
|---|---|
| Sulphate of Lime | 7·4 |
| Chloride of Sodium | 1·3 |
| Sulphate of Soda<br>Organic matter<br>Oxide of Iron<br>Trace of Potash<br>Trace of Alumina | 1·3 |
| Contents in Imperial Gallon | 10·0 |

SAMPLE II.—Marked N.F.

| | Grains. |
|---|---|
| Sulphate of Lime | 3·5 |
| Chloride of Sodium | 1·2 |
| Sulphate of Soda | 0·8 |
| Silica<br>Oxide of Iron<br>Organic matter<br>Trace of Potash<br>Trace of Alumina | 2·1 |
| Contents in Imperial Gallon | 7·6 |

SAMPLE III.—Marked F.H.

| | Grains. |
|---|---|
| Sulphate of Lime | 20·00 |
| Chloride of Sodium | 1·95 |
| Sulphate of Soda | 2·20 |
| Sulphate of Magnesia<br>Silica<br>Traces of a Nitrate | 1·79 |
| Contents in Imperial Gallon | 25·94 |

HARDNESS.—The hardness of these waters, expressed in terms having reference to distilled water as = 1, and also as determined by Dr. Clarke's test, stands as follows:—

| Number and Mark of Sample. | Hardness in Reference to Distilled Water as = 1. | Hardness in terms of Dr. Clarke's Test. |
|---|---|---|
| 1. C. G. No. 3 | 7·9 | 7·0 |
| 2. N. F. | 5·6 | 6·0 |
| 3. F. H. | 19·0 | 18·2 |

ACTION ON LEAD.—These waters do not exert any injurious action upon metallic lead.

*REMARKS.*—Of the above waters, C.G. and N.F. are comparatively soft; they are well aerated, but are not sufficiently pellucid for general domestic purposes, and if required for the table they should be filtered, inasmuch as from the finely divided state of the matters they hold in suspension, they do not readily become clear by mere subsidence; after filtration, both of these samples, but more especially N.F., may be considered as good water. It will be observed in regard to sample F.H., that it contains about three times as much sulphate of lime as sample 1, and nearly six times as much as sample 2; it is therefore an inconveniently *hard* water, and although unexceptionable as to brightness and aeration, it would be objectionable for many culinary and domestic uses. All these waters are free from any trace of copper or of arsenic.

I remain, SIR,

Your faithful Servant,

(Signed) WILLIAM THOS. BRANDE.

MICHAEL SCOTT, ESQ., C.E., &c.,
26, *Great George Street, Westminster.*

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KEY *to the* MARKS *on the* SAMPLES, *referred to in* PROFESSOR BRANDE'S ADDITIONAL REPORT.

No. 1.—C.G. No. 3, 30th April, Cwmgelly Waters, below the Junction of the two Brooks.
No. 2.—N.F., 1st May, Nant-felyn Brook.
No. 3.—F.H., 30th April, Foxhole Brook.

Samples taken by JAMES HALL.

# APPENDIX.

## No. I.—Population *of the* Parishes *of* Swansea, St. Thomas, *and* St. John, *according to the Census of* 1831, 1841, *and* 1851.

| | Houses. | | | | | | | | | Total number of Persons. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inhabited. | | | Uninhabited. | | | Building. | | | | | |
| | 1831 | 1841 | 1851 | 1831 | 1841 | 1851 | 1831 | 1841 | 1851 | 1831 | 1841 | 1851 |
| Swansea Parish, viz., Swansea Town and Franchise | 2,582 | 3,166 | 4,057 | 132 | 139 | 181 | 24 | 64 | 57 | 13,256 | 16,787 | 21,482 |
| St. Thomas, within the Borough . . . . | 79 | 112 | 215 | 6 | 5 | 4 | 2 | .. | 1 | 438 | 683 | 1,089 |
| St. John's Parish, within the Borough . . . | 139 | 195 | 231 | 3 | 12 | 15 | 10 | .. | 1 | 670 | 1,037 | 1,178 |
| Totals . . . | 2,800 | 3,473 | 4,503 | 141 | 156 | 200 | 36 | 64 | 59 | 14,364 | 18,507 | 23,749 |

Average number of Inhabitants to each House in 1851, including Vacant and Building . $4 \cdot \frac{99}{100}$

Population in 1831 . . . . . 14,364
Ditto in 1841 . . . . . 18,507

Increase in 10 years . . 4,143 or 28·8 per cent.

Population in 1841 . . . . . 18,507
Ditto in 1851 . . . . . 23,748

Increase in 10 years . . 5,241 or 28·3 per cent.

Total increase in 20 years 9,384 or 67·3 per cent.

Note.—At the average rate of 28½ per cent. in 10 years, the population will be doubled in 28 years.

## No. II.—Population *of the* District *proposed to be Supplied.*—1851.

| | Houses, including Vacant. | Population, (five to each House) |
|---|---|---|
| **Swansea.** | | |
| Town Proper . . . . | 4,182 | 20,910 |
| Hamlet of St. Thomas . . | 105 | 525 |
| Parish of Llansamlet . . | 379 | 1,895 |
| " St. John's . . | 177 | 885 |
| " Llangafelach . . | 177 | 885 |
| Totals | 5,020 | 25,100 |
| **Morriston.** | | |
| Clase Lower . . . . . | 344 | 1,720 |
| Clase Higher . . . . | 28 | 140 |
| | 372 | 1,860 |

## No. III.—Table *of* Rain-fall *at* Swansea, *in Inches, as observed by* Mr. Jenkins.

| Month. | 1842 | 1843 | 1844 | 1845 | 1846 | 1847 | 1848 | 1849 | 1850 | 1851 | 1852 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | .. | 3·20 | 3·12 | 3·23 | 6·12 | 2·62 | 2·24 | 3·88 | 1·63 | 6·24 | 6·94 |
| February | .. | 1·47 | 3·44 | 2·51 | 1·92 | 2·48 | 6·43 | 2·03 | 3·07 | 2·76 | 2·17 |
| March | .. | 1·59 | 3·28 | 2·39 | 2·43 | 2·67 | 3·99 | 1·30 | 0·52 | 4·26 | 0·51 |
| April | .. | 3·61 | 1·15 | 2·50 | 2·51 | 1·51 | 3·60 | 2·30 | 4·41 | 1·79 | 2·11 |
| May | .. | 2·82 | 0·08 | 1·19 | 1·82 | 3·15 | 2·26 | 3·37 | 2·08 | 1·35 | .. |
| June | 1·42 | 3·77 | 1·27 | 3·19 | 1·68 | 2·73 | 3·46 | 0·92 | 2·01 | 2·52 | .. |
| July | 1·97 | 2·25 | 1·79 | 3·46 | 3·84 | 2·55 | 3·53 | 2·56 | 1·55 | 3·84 | .. |
| August | 1·44 | 2·87 | 4·97 | 6.46 | 3·32 | 3·88 | 5·62 | 2·58 | 3·30 | 2·27 | .. |
| September | 4·08 | 0·62 | 1·00 | 3·93 | 2·05 | 2·81 | 2·78 | 2·84 | 3·82 | 0·98 | .. |
| October | 3·00 | 4·91 | 5·34 | 2·00 | 5·10 | 5·47 | 4·64 | 3·77 | 2·05 | 4·18 | .. |
| November | 9·60 | 4·72 | 3·85 | 4·32 | 3·35 | 2·80 | 2·75 | 2·54 | 4·61 | 1·87 | .. |
| December | 3·57 | 1·13 | 0·46 | 4·46 | 2·09 | 3·58 | 4·98 | 3·86 | 3·96 | 1·64 | .. |
| Totals | .. | 32·96 | 29·75 | 39·64 | 36·23 | 36·25 | 46·28 | 31·95 | 33·01 | 33·70 | .. |

No. IV.—TABLE, *shewing the* AVERAGE RAIN-FALL *at* SWANSEA, *at different periods of the Year.*

| Rain-fall in each Month. (Mean from No. III.) | | Rain-fall in 6 Months, at different periods of the Year. (Mean from No. III.) | | Rain-fall in 3 Months, at different periods of the Year. (Mean from No. III.) | |
|---|---|---|---|---|---|
| Month. | Inches. | Six Months, ending | Inches. | Three Months, ending | Inches. |
| January . . | 3·922 | January . . | 21·144 | January . . | 10·936 |
| February . . | 2·828 | February . . | 20·301 | February . . | 9·723 |
| March . . | 2·294 | March . . | 20·104 | March . . | 9·044 |
| April . . | 2·598 | April . . . | 18·656 | April . . . | 7·720 |
| May . . . | 2·013 | May . . . | 16·628 | May . . . | 6·905 |
| June . . . | 2·297 | June . . . | 15·952 | June . . . | 6·908 |
| July . . . | 2·734 | July . . . | 14·764 | July . . . | 7·044 |
| August . . | 3·671 | August . . | 15·607 | August . . | 8·702 |
| September . | 2·491 | September . | 15·808 | September . | 8·896 |
| October . . | 4·046 | October . . | 17·252 | October . . | 10·208 |
| November . | 4·041 | November . | 19·280 | November . | 10·578 |
| December . | 2·973 | December . | 19·956 | December . | 11·060 |

No. V.—STATEMENT *of the* AMOUNT *of* WATER RENTS, *according to the scale proposed in the* BILL *pending in Parliament, calculated on the* POPULATION *in* 1851. [*See* Nos. I. and II.]

*Town of* SWANSEA.

| Class of Houses. | | No. of Houses. | Assumed average Rent. | Total Rent, calculated from preceding Column. | Rate. | Amount. |
|---|---|---|---|---|---|---|
| | | | £. s. d. | £. s. d. | per House. | £. s. d. |
| Not exceeding . . . . . . | £5 | 2,004 | .. | .. | 7*s*. 6*d*. | 751 10 0 |
| Exceeding £5, not exceeding . | 7 | 509 | .. | .. | 8*s*. 6*d*. | 216 6 6 |
| „ 7, „ | 10 | 498 | 8 10 0 | 4,233 0 0 | per Cent. 6½ | 275 3 0 |
| „ 10, „ | 20 | 790 | 15 0 0 | 11,850 0 0 | 6 | 711 0 0 |
| „ 20, „ | 40 | 271 | 30 0 0 | 8,130 0 0 | 5½ | 447 3 0 |
| „ 40, „ | 60 | 87 | 50 0 0 | 4,350 0 0 | 5 | 217 10 0 |
| „ 60, „ | — | 23 | 80 0 0 | 1,840 0 0 | 4½ | 82 16 0 |
| | | 4,182 | | | £ | 2,701 8 6 |

*Hamlet of* ST. THOMAS.

| Class of Houses. | | No. of Houses. | Assumed average Rent. | Total Rent, calculated from preceding Column. | Rate. | Amount. |
|---|---|---|---|---|---|---|
| Not exceeding . . . . . . | £5 | 82 | .. | .. | 7*s*. 6*d*. | 30 15 0 |
| Exeeeding £7, not exceeding . | 10 | 10 | 8 10 0 | 85 0 0 | per Cent. 6½ | 5 10 6 |
| „ 10, „ | 20 | 13 | 15 0 0 | 195 0 0 | 6 | 11 14 0 |
| | | 105 | | | | £47 19 6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | **Parish of Llansamlet.** | | | | |
| Not exceeding . . . . . . | £5 | 355 | .. | .. | 7*s.* 6*d.* | 133 2 6 |
| Exceeding £5, not exceeding . | 7 | 8 | .. | .. | 8*s.* 6*d.* | 3 8 0 |
| „ 7, „ | 10 | 5 | 8 10 0 | 42 10 0 | per Cent. 6½ | 2 15 3 |
| „ 10, „ | 20 | 11 | 15 0 0 | 165 0 0 | 6 | 9 18 0 |
| | | 379 | | | | £149 3 9 |
| | | **Parish of St. John.** | | | | |
| Not exceeding . . . . . . | £5 | 146 | .. | .. | 7*s.* 6*d.* | 54 15 0 |
| Exceeding £5, not exceeding . | 7 | 5 | .. | .. | 8*s.* 6*d.* | 2 2 6 |
| „ 7, „ | 10 | 25 | 8 10 0 | 212 10 0 | per Cent. 6½ | 13 16 3 |
| „ 10, „ | 20 | 1 | 15 0 0 | 15 0 0 | 6 | 0 18 0 |
| | | 177 | | | | £71 11 9 |
| | | **Hamlet of Clase—Parish of Llangafelach.** | | | | |
| Not exceeding . . . . . . | £5 | 153 | .. | .. | 7*s.* 6*d.* | 57 7 6 |
| Exceeding £5, not exceeding . | 7 | 9 | .. | .. | 8*s.* 6*d.* | 3 16 6 |
| „ 7, „ | 10 | 6 | 8 10 0 | 51 0 0 | per Cent. 6½ | 3 6 3 |
| „ 10, „ | 20 | 9 | 15 0 0 | 135 0 0 | 6 | 8 2 0 |
| | | 177 | | | | £72 12 3 |

## Summary.

| | No. of Houses. | £ s. d. | £. s. d. |
|---|---|---|---|
| Town of Swansea . . . . | 4,182 | .. | 2,701 8 6 |
| Hamlet of St. Thomas . . | 105 | .. | 47 19 6 |
| Parish of Llansamlet . . . | 379 | .. | 149 3 9 |
| Parish of St. John . . . . | 177 | .. | 71 11 9 |
| Hamlet of Clase . . . . | 177 | .. | 72 12 3 |
| | 5,020 | | £3,042 15 9 |
| Supplies to Shipping . . . | .. | 200 0 0 | |
| " Trades . . . | .. | 200 0 0 | |
| " Sanitary purposes . | .. | 200 0 0 | |
| | | | 600 0 0 |
| Total . . | .. | .. | £3,642 15 9 |

## Morriston.

| Class of Houses. | Number of Houses. | Total Rental. | Rate. | Amount. | Total. |
|---|---|---|---|---|---|
| **Clase Lower.** | | £ s. d. | | £ s. d. | £ s. d. |
| Not exceeding £5 . . | 313 | .. | per house 7s. 6d. | 117 7 6 | |
| Exceeding £5 and not exceeding £7 . . | 19 | 160 0 0 | per Cent. 6¼ | 10 8 0 | |
| Exceeding £10 and not exceeding £20 . . | 12 | 143 0 0 | 6 | 8 12 0 | |
| | | | | | 136 7 6 |
| **Clase Higher.** | | | | | |
| Not exceeding £5 . | 22 | .. | per house 7s. d. | 8 5 0 | |
| Exceeding £7 and not exceeding £10 . . | 4 | 34 0 0 | per Cent. 6¼ | 2 4 2 | |
| Exceeding £10 and not exceeding £20 . . | 2 | 24 10 0 | 6 | 1 9 5 | |
| | | | | | 11 18 7 |
| | 372 | | | £ | 148 6 1 |

## No. VI.—STATEMENT *of the* INCOME, *calculated on the* POPULATION *for last year,* 1851. (*See* No. V.)

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Total Rental from Houses . . . . . . . . . | | | | 3,042 | 15 | 9 |
| (Showing a mean of 12*s.* 1*d.* per House) | | | | | | |
| Deduct empty Houses, 197 at 12*s.* 1*d.* . . . . . | | | | 119 | 0 | 9 |
| | | | | 2,923 | 15 | 0 |
| Deduct Bad Debts, and Collecting, 7 per Cent. . . . | | | | 204 | 15 | 0 |
| | | | | £2,719 | 0 | 0 |
| Supplies to Shipping . . . . . | 200 | 0 | 0 | | | |
| ,, Trades . . . . . . . | 200 | 0 | 0 | | | |
| ,, Sanitary purposes . . . | 200 | 0 | 0 | | | |
| | | | | 600 | 0 | 0 |
| | | | | £3,319 | 0 | 0 |

## No. VII.—STATEMENT *of the* INCOME *when the Works would be completed, and the whole District supplied, allowing an increase of* 8½ *per Cent. on the Population in* 1851. (*See* No. VI.)

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Total Rental from Houses . . . . . . . . . | | | | 3,302 | 0 | 0 |
| (Showing a mean of 12*s.* 1*d.* per House) | | | | | | |
| Deduct empty Houses, 214 at 12*s.* 1*d.* . . . . . | | | | 129 | 5 | 10 |
| | | | | 3,172 | 14 | 2 |
| Deduct Bad Debts, and Collecting, 7 per Cent. . . | | | | 222 | 4 | 2 |
| | | | | £2,950 | 10 | 0 |
| Supplies to Shipping . . . . . | 217 | 0 | 0 | | | |
| ,, Trades . . . . . . | 217 | 0 | 0 | | | |
| ,, Sanitary purposes . . . | 217 | 0 | 0 | | | |
| | | | | 651 | 0 | 0 |
| | | | | £3,601 | 10 | 0 |

No. VIII.—ESTIMATED COST *of the proposed new* WORKS *in the* WESTERN DISTRICT, *combined with the existing Company's Works, including Reservoirs, Pumping Machinery, Mains, Service Reservoirs, Service Pipes, and other Works, for the supply of the* TOWN *of* SWANSEA *and neighbouring Population, amounting to* 27,500, *or about* 8½ *per Cent. increase on the Population in* 1851. (*See* No. II.)

| | £ s. d. |
|---|---|
| Fynone Tank, and Main from ditto to Mount Pleasant Tank . . . . . . . . | |
| Mount Pleasant Tanks . . . . . . | |
| Foxhole Tank, and Pumping Machinery, for supplying that district during certain periods . | |
| Service Reservoir, in Dyvatty Field . . . | |
| Service Reservoir, at Wain Wen . . . | |
| Two small Tanks, Culvert, and large Tank at Pen-y-filia . . . . . . . . | |
| Storage Reservoir, at Bryn Mill, with Embankments, Masonry, Pipes, Sluices, Overflow and Guage Weirs, Pitching, Roads, &c. . . . . | |
| Conduits, to convey water into proposed Storage Reservoirs . . . . . . . | |
| Tank, at Engine Station . . . . . . | |
| Pumping Machinery, for raising water . . | |
| Fencing round Reservoirs, Pumping Station, &c. . | |
| Purchase of Land, and Compensation . . . | |
| Leading Mains, conveying water to Pumping Station, and to Town . . . . . . | |
| Works of distribution, including Mains, Service Pipes, Cocks, and Hydrants . . . . | |
| Filters . . . . . . . . . . | |
| Contingencies, 10 per cent. . . . . . | |
| Working Expenses of Pumping Machinery, capitalized, at 5 per cent., in order to make this comparable with other capital statements . . | |
| Total . . . . . | £ |
| Deduct value of Company's Pipeage . . . . . | |
| Leaving . . . . | £ |
| Add for purchase of Company's Works . . | |
| Add Compensation to Mr. Vivian, for Water . | |
| Grand Total . . . . | £65,000 0 0 |

No. IX.—Estimated Cost *of the proposed* Works *in the* Cwmgelly District, *including Reservoirs, Mains, Service Reservoirs, Service Pipes, and other Works, for the supply of the* Town *of* Swansea *and neighbouring Population, amounting to* 27,500, *or about* 8½ *per Cent. increase on the Population in* 1851. (*See* No. II.)

---

| | £ s. d. |
|---|---|
| Foxhole Tank and Pumping Machinery, for supplying that district during certain periods . | |
| Service Reservoir, in Dyvatty Field . . . | |
| Service Reservoir, at Wain Wen . . . | |
| Four small Tanks, Culvert, and large Tank, at Pen-y-filia . . . . . . . | |
| Lower Storage Reservoir, at Cwmgelly, with Embankment, Masonry, Pipes, Sluices, Overflow and Guage Weirs, Pitching, Roads, Sluice Tower, Piers, and Bridge . . . . | |
| Conduit, to convey water past the Reservoir . | |
| Fencing round Reservoirs, &c. . . . | |
| Purchase of Land, and Compensation . . | |
| Leading Mains, conveying water to Service Reservoirs, and to Town . . . . . . | |
| Works of distribution, including Mains, Service Pipes, Cocks, and Hydrants . . . | |
| Filters . . . . . . . | |
| Contingencies, 10 per Cent. . . . . | |
| Total . . . . | £35,000 0 0 |

No. X.—Estimated Cost *of the proposed* Works *in the* Western District, *combined with the existing Company's Works and new sources, including Reservoirs, Pumping Machinery, Mains, Service Reservoirs, Service Pipes, and other Works, for the supply of the* Town *of* Swansea *and neighbouring Population, when it shall amount to* 55,000.

| | £. | *s.* | *d.* |
|---|---|---|---|
| Fynone Tank, and Main from ditto to Mount Pleasant Tank . . . . . . | | | |
| Mount Pleasant Tanks . . . . . | | | |
| Foxhole Tank and Pumping Machinery, for supplying that district during certain periods . | | | |
| Service Reservoir, in Dyvatty Field . . . | | | |
| Service Reservoir, at Wain Wen . . . | | | |
| Two small Tanks, Culvert, and Large Tanks, at Pen-y-filia . . . . . . . | | | |
| Storage Reservoir at Bryn Mill, with Embankments, Masonry, Pipes, Sluices, Overflow and Guage Weirs, Pitching, Roads, &c. . . | | | |
| Conduits, to convey water into proposed Storage Reservoir . . . . . . . | | | |
| Tank at Engine Station . . . . . | | | |
| Pumping Machinery, for raising water . . | | | |
| Fencing round Reservoirs, Pumping Station, &c. . | | | |
| Purchase of Land, and Compensation . . | | | |
| Leading Mains, conveying water to Pumping Station, and to Town . . . . . . | | | |
| Works of Distribution, including Mains, Service Pipes, Cocks, and Hydrants . . . | | | |
| Filters . . . . . . . . | | | |
| Contingencies, 10 per Cent. . . . . | | | |
| Working Expenses of Pumping Machinery, capitalized, at 5 per cent., in order to make this comparable with other capital statements . | | | |
| Total . . . . £ | | | |
| Deduct value of Company's Pipeage . . | | | |
| Leaving . . . . £ | | | |
| Add for purchase of Company's Works . . | | | |
| Add Compensation to Mr. Vivian, for Water . | | | |
| Grand Total . . . | £91,000 | 0 | 0 |

No. XI.—Estimated Cost *of the proposed* Works *in the* Cwmgelly District, *including Reservoirs, Mains, Service Reservoirs, Service Pipes, and other Works, for the supply of the* Town *of* Swansea *and neighbouring Population, when it shall amount to* 55,000.

| | £ | *s.* | *d.* |
|---|---|---|---|
| Fynone Tank, and Main from ditto to Mount Pleasant Tank . . . . . . . | | | |
| Mount Pleasant Tanks . . . . . . | | | |
| Foxhole Tank and Pumping Machinery, for supplying that district during certain periods . . | | | |
| Service Reservoir, in Dyvatty Field . . . | | | |
| Service Reservoir, at Wain Wen . . . | | | |
| Four small Tanks, Culvert, and large Tanks, at Pen-y-filia . . . . . . . | | | |
| Lower Storage Reservoir, at Cwmgelly, with Embankment, Masonry, Pipes, Sluices, Overflow and Guage Weirs, Pitching, Roads, Sluice Tower, Piers, and Bridge . . . . . . | | | |
| Upper Storage Reservoir, at Cwmgelly . . | | | |
| Conduit, to convey water past Reservoirs . . | | | |
| Fencing round Reservoirs . . . . . | | | |
| Purchase of Land, and Compensation . . | | | |
| Leading Mains, conveying water to Service Reservoirs, and to Town . . . . . . | | | |
| Works of distribution, including Mains, Service Pipes, Cocks, and Hydrants . . . . . | | | |
| Filters . . . . . . . . . . . | | | |
| Contingencies, 10 per Cent. . . . . | | | |
| Total . . | £50,000 | 0 | 0 |

For several reasons, amongst which may be mentioned an advancing iron market, a considerable margin has been allowed in these Estimates.

## No. XII.—Statement *of the* Annual Income *and* Expenditure, *compared for the* Present *and for the* Prospective Population.

### PRESENT POPULATION.

| | | |
|---|---|---|
| 1. Western District Works. | | |
| Income.—Water Rents, according to scale proposed in Bill before Parliament. (*See* No. V.) . . . . . . . | | £3,601 |
| Expenditure.—Interest on Capital, assumed at £65,000, taken at 5 per cent. | £3,250 | |
| Working Expenses . . . | 1,287 | |
| | | 4,537 |
| *Deficiency* . . . . | | £930 |
| 2. Cwmgelly Works. | | |
| Income.—Water Rents, as before . . . | | £3,601 |
| Expenditure.—Interest on Capital, assumed at £35,000, taken at 5 per cent. | £1,750 | |
| Working Expenses . . . | 937 | |
| | | 2,687 |
| *Surplus* . . . . . | | £914 |

### PROSPECTIVE POPULATION.

| | | |
|---|---|---|
| 1. Western District Works. | | |
| Income.—Calculated as before, and doubled . | | £7,202 |
| Expenditure.—Interest on Capital, assumed at £91,000, taken at 5 per cent. | £4,550 | |
| Working Expenses, doubled . | 2,574 | |
| | | 7,124 |
| *Surplus* . . . . . | | £78 |
| 2. Cwmgelly Works. | | |
| Income.—As before, doubled . . . . . | | £7,202 |
| Expenditure.—Interest on Capital, assumed at £50,000, taken at 5 per cent. | £2,500 | |
| Working Expenses, doubled . | 1,874 | |
| | | 4,374 |
| *Surplus* . . . . . | | £2,828 |

Note.—By "present population," is meant the population when the works would be completed and in full operation, assumed at 27,500.

## No. XIII.—Statement *of the* Annual Income *and* Expenditure, *the Rate of Interest being assumed at* 4 *per Cent. per Annum.*

### PRESENT POPULATION.

1. Western District Works.

| | | |
|---|---|---|
| Income.—Water Rents, calculated on the scale proposed in Bill before Parliament . . . . . . . . . . | | £3,601 |
| Expenditure.—Interest on Capital, £65,000, at 4 per Cent. . . . . . | £2,600 | |
| Working Expenses . . . . | 1,287 | |
| | | 3,887 |
| *Deficiency* . . . . . | | £286 |

2. Cwmgelly Works.

| | | |
|---|---|---|
| Income.—Water Rents as before . . . | | £3,601 |
| Expenditure.—Interest on Capital, £35,000, at 4 per cent. . . . . | £1,400 | |
| Working Expenses . . . . | 937 | |
| | | 2,337 |
| *Surplus* . . . . . . | | £1,264 |

### PROSPECTIVE POPULATION.

1. Western District Works.

| | | |
|---|---|---|
| Income.—Water Rents as before, doubled . | | £7,202 |
| Expenditure.—Interest on Capital, £91,000, at 4 per Cent . . . . | £3,640 | |
| Working Expenses . . . . | 2,574 | |
| | | 6,214 |
| *Surplus* . . . . . . . | | £988 |

2. Cwmgelly Works.

| | | |
|---|---|---|
| Income.—Water Rents as before, doubled . | | £7,202 |
| Expenditure.—Interest on Capital, £50,000, at 4 per Cent. . . . . | £2,000 | |
| Working Expenses . . . . | 1,874 | |
| | | 3,874 |
| *Surplus* . . . . . . | | £3,328 |

Note.—For certain reasons a large margin has been allowed in the item of Working Expenses.

No. XIV.—*From the* Statement *of* Income *and* Expenditure, No. XIII., *it appears, that, the Rate of Interest being assumed at* 4 *per Cent.,*

*For the* PRESENT POPULATION,

| | |
|---|---|
| The Western District Works would involve an *increase* in the rates proposed, of . . . . | 8 per Cent. |
| The Cwmgelly Works would admit of a *reduction* of . . . . . . . . . . . . . | 35 ,, |

And that

*For the* PROSPECTIVE POPULATION,

| | |
|---|---|
| The Western District Works would admit of a *reduction* of . . . . . . . . . . . | 13¾ ,, |
| The Cwmgelly Works would admit of a *reduction* of . . . . . . . . . . . . . | 46¼ ,, |

The rates in the last case being as under:—

| | Per Annum. |
|---|---|
| For Houses not exceeding £5 rent, | 4*s*. 0*d*. per House. |
| Ditto exceeding £5, not exceeding £7, | 4*s*. 7*d*. ,, |
| Ditto exceeding £7, not exceeding £10, | 3½ per Cent. |
| Ditto exceeding £10, not exceeding £20, | 3¼ ,, |
| Ditto exceeding £20, not exceeding £40, | 3 ,, |
| Ditto exceeding £40, not exceeding £60, | 2¾ ,, |
| Ditto exceeding £60 . . . . . | 2½ ,, |

No. XV.—Table *showing the* Direction *of the* Wind *at* Swansea, *in the* Years 1849, 1850, *and* 1851, *from* Observations *by* Mr. Jenkins.

| 1849. Month. | N. | N. by E. | N.N.E. | N.E. by N. | N.E. | N.E. by E. | E.N.E. | E. by N. | E. | E. by S. | E.S.E. | S.E. by E. | S.E. | S.E. by S. | S.S.E. | S. by E. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 2 | .. | .. | .. | .. | .. | .. | .. | 2 | .. | 3 | .. | 1 | .. | 2 | .. |
| February | .. | .. | .. | .. | 5 | .. | .. | .. | .. | .. | .. | .. | 4 | .. | .. | .. |
| March | .. | .. | .. | .. | 4 | .. | 2 | .. | 2 | .. | .. | .. | 8 | .. | .. | .. |
| April | 2 | .. | .. | .. | 4 | .. | .. | .. | .. | .. | .. | .. | 3 | .. | 1 | .. |
| May | .. | .. | .. | .. | 2 | .. | 3 | .. | 1 | .. | .. | .. | 3 | .. | .. | .. |
| June | 3 | .. | 1 | .. | 1 | .. | 1 | .. | .. | .. | .. | .. | 2 | .. | .. | .. |
| July | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .. | .. | .. | .. | .. |
| August | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 2 | 1 |
| September | 2 | .. | .. | .. | 3 | .. | 2 | .. | 3 | .. | .. | .. | 5 | .. | 3 | .. |
| October | 1 | .. | 1 | .. | 5 | .. | 1 | .. | .. | .. | 1 | .. | 4 | .. | 1 | .. |
| November | 1 | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. | 7 | .. | 1 | 1 |
| December | 3 | .. | .. | .. | 6 | .. | 2 | .. | .. | .. | 1 | .. | 1 | .. | 1 | .. |
| | 14 | .. | 2 | .. | 31 | .. | 11 | .. | 9 | .. | 6 | .. | 39 | .. | 11 | 2 |

| 1849. Month. | S. | S. by W. | S.S.W. | S.W. by S. | S.W. | S.W. by W. | W.S.W. | W. by S. | W. | W. by N. | W.N.W. | N.W. by W. | N.W. | N.W. by N. | N.N.W. | N. by W. | Calm. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 1 | .. | .. | .. | 11 | .. | 2 | .. | .. | .. | 3 | .. | 2 | .. | 2 | .. | .. |
| February | 1 | .. | .. | .. | 7 | .. | .. | .. | 4 | .. | .. | .. | 5 | .. | 1 | .. | 1 |
| March | .. | .. | .. | .. | 2 | .. | .. | .. | 1 | .. | 1 | .. | 5 | .. | 5 | .. | 1 |
| April | 1 | .. | 4 | .. | 2 | .. | .. | .. | 2 | .. | 5 | .. | 4 | .. | 1 | .. | 1 |
| May | .. | .. | .. | .. | 13 | .. | 2 | .. | 1 | .. | 1 | .. | 1 | .. | .. | .. | 4 |
| June | .. | .. | 1 | .. | 7 | .. | .. | .. | 2 | 1 | 2 | .. | 3 | .. | 2 | .. | 4 |
| July | 1 | .. | .. | .. | 5 | .. | 1 | .. | 4 | .. | 1 | .. | 11 | .. | 2 | .. | 4 |
| August | .. | .. | 3 | .. | 4 | .. | .. | .. | 1 | 1 | 6 | .. | 8 | .. | .. | .. | 4 |
| September | 1 | .. | 1 | .. | 2 | .. | .. | .. | .. | .. | .. | .. | 3 | .. | 1 | .. | 4 |
| October | 1 | .. | 2 | .. | 4 | .. | 2 | .. | 1 | .. | 2 | .. | 1 | .. | .. | .. | 4 |
| November | 1 | .. | .. | .. | 4 | .. | 1 | .. | .. | .. | .. | .. | 7 | .. | 2 | .. | 4 |
| December | .. | .. | 4 | .. | 2 | .. | .. | .. | 1 | .. | 1 | .. | 2 | .. | 3 | .. | 4 |
| | 7 | .. | 15 | .. | 63 | .. | 8 | .. | 17 | 2 | 22 | .. | 52 | .. | 9 | .. | 35 |

(continued)

## TABLE *showing the* DIRECTION *of the* WIND *at* SWANSEA—(*continued*).

| 1850 | N. | N. by E. | N.N.E. | N.E. by N. | N.E. | N.E. by E. | E.N.E. | E. by N. | E. | E. by S. | E.S.E. | S.E. by E. | S.E. | S.E. by S. | S.S.E. | S. by E. | S. | S. by W. | S.S.W. | S.W. by S. | S.W. | S.W. by W. | W.S.W. | W. by S. | W. | W. by N. | W.N.W. | N.W. by W. | N.W. | N.W. by N. | N.N.W. | N. by W. | Calm. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTH. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January | .. | .. | 1 | .. | .. | .. | 2 | .. | 5 | .. | 1 | .. | 9 | .. | 1 | .. | .. | .. | .. | .. | 2 | .. | .. | .. | 1 | .. | .. | .. | 3 | .. | 3 | .. | 3 |
| February | 3 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | 1 | .. | 1 | .. | 3 | .. | .. | .. | 4 | .. | 2 | .. | 7 | .. | 4 | .. | 2 |
| March | 3 | .. | .. | .. | 3 | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .. | .. | .. | .. | .. | 8 | .. | .. | .. | 2 | .. | .. | .. | 4 | .. | 3 | .. | 6 |
| April | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 8 | .. | 1 | .. | 1 | .. | 1 | .. | 9 | .. | .. | .. | 1 | .. | .. | .. | 1 | .. | .. | .. | 7 |
| May | 2 | .. | .. | .. | 5 | .. | 1 | .. | .. | .. | .. | .. | 1 | .. | .. | .. | .. | .. | 1 | .. | 5 | .. | .. | .. | 2 | .. | 2 | .. | 4 | .. | 1 | .. | 7 |
| June | 2 | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .. | .. | .. | 2 | .. | 3 | .. | 1 | .. | 10 | .. | 2 | .. | 3 | .. | .. | .. | 4 |
| July | 3 | .. | .. | .. | 2 | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .. | 2 | .. | .. | 6 | .. | .. | 2 | .. | 4 | .. | .. | .. | 5 | .. | 3 | .. | 2 |
| August | 3 | .. | 1 | .. | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | .. | .. | 7 | .. | .. | .. | 4 | .. | 2 | .. | 4 | .. | 3 | .. | 4 |
| September | .. | .. | .. | .. | .. | .. | 1 | .. | 2 | .. | 2 | .. | 6 | .. | 2 | .. | .. | .. | .. | .. | 4 | .. | .. | .. | 1 | .. | .. | .. | 1 | .. | 6 | .. | 5 |
| October | 5 | .. | .. | .. | .. | 2 | .. | .. | .. | .. | .. | .. | 2 | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .. | 2 | .. | 2 | .. | 11 | .. | 1 | .. | 4 |
| November | 1 | .. | .. | .. | 2 | .. | .. | .. | .. | .. | 1 | .. | 4 | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .. | 6 | .. | 1 | .. | 9 | .. | 1 | .. | 3 |
| December | .. | .. | .. | .. | 2 | .. | .. | .. | .. | .. | .. | .. | 9 | .. | .. | .. | .. | .. | 1 | .. | 5 | .. | .. | .. | 3 | .. | .. | .. | 6 | .. | 1 | .. | 4 |
| | 23 | .. | 2 | .. | 17 | 2 | 4 | .. | 7 | .. | 4 | .. | 43 | .. | 8 | .. | 4 | .. | 6 | 6 | 48 | .. | 5 | .. | 40 | .. | 11 | .. | 58 | .. | 26 | .. | 51 |
| 1851. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January | .. | .. | .. | .. | 1 | .. | .. | .. | .. | .. | 1 | .. | .. | .. | 3 | 3 | 2 | .. | 4 | .. | 10 | .. | .. | .. | 7 | .. | .. | .. | .. | .. | .. | .. | .. |
| February | .. | .. | .. | .. | 7 | .. | .. | .. | .. | .. | 1 | .. | 6 | .. | .. | .. | 2 | .. | .. | .. | 7 | .. | .. | .. | 2 | .. | .. | .. | 3 | .. | .. | .. | .. |
| March | 2 | 1 | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 2 | .. | .. | .. | 2 | .. | 2 | .. | 3 | .. | .. | .. | 4 | .. | 4 | .. | 7 | .. | 3 | .. | .. |
| April | 3 | .. | .. | .. | 2 | .. | .. | .. | 2 | .. | 3 | .. | 2 | .. | 1 | .. | .. | .. | .. | .. | 12 | .. | .. | .. | 1 | .. | .. | .. | 3 | .. | 1 | .. | .. |
| May | 2 | .. | 1 | .. | 5 | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 2 | .. | .. | .. | .. | .. | 9 | .. | .. | .. | 1 | .. | .. | .. | 6 | .. | 4 | .. | .. |
| June | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 3 | .. | .. | .. | .. | .. | 1 | .. | 10 | .. | .. | .. | 4 | .. | 3 | .. | 5 | .. | 1 | .. | .. |
| July | 2 | .. | .. | .. | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 3 | .. | 1 | .. | 6 | .. | .. | .. | 5 | .. | 1 | .. | 5 | .. | 6 | .. | .. |
| August | 1 | .. | 1 | .. | .. | .. | 1 | .. | 2 | .. | .. | .. | .. | .. | 2 | .. | 4 | .. | 2 | .. | 8 | .. | 1 | .. | 4 | .. | .. | .. | 3 | .. | 2 | .. | .. |
| September | 3 | .. | .. | .. | 5 | .. | 1 | .. | 4 | .. | .. | .. | 3 | .. | .. | .. | 2 | .. | .. | .. | 4 | .. | .. | .. | 1 | .. | .. | .. | 4 | .. | .. | .. | 3 |
| October | .. | .. | 1 | .. | 2 | .. | .. | .. | 1 | .. | .. | .. | 4 | .. | .. | .. | 1 | .. | 1 | .. | 5 | .. | .. | .. | 8 | .. | .. | .. | 8 | .. | .. | .. | .. |
| November | 7 | .. | 1 | .. | 7 | .. | .. | .. | 1 | .. | .. | .. | 1 | .. | .. | .. | .. | .. | 1 | .. | 1 | .. | .. | .. | .. | .. | .. | .. | 7 | .. | 3 | .. | 1 |
| December | 1 | .. | .. | .. | 6 | .. | .. | .. | .. | .. | .. | .. | 11 | .. | .. | .. | .. | .. | .. | .. | 6 | .. | .. | .. | 1 | .. | .. | .. | 6 | .. | .. | .. | .. |
| | 23 | 1 | 5 | .. | 37 | .. | 2 | .. | 10 | .. | 6 | .. | 33 | .. | 8 | 3 | 16 | .. | 12 | .. | 81 | .. | 1 | .. | 38 | .. | 8 | .. | 57 | .. | 20 | .. | 4 |

G 1852.

| ST | ON EACH DAY. | | | |
|---|---|---|---|---|
| | . | 18th. | 19th. | 20th. |
| Cwmgelly B | 050 | 240,149 | 247,710 | 106, |
| Pen-y-filia B | 101 | 157,842 | 150,016 | 161, |
| Ditto | ,350 | 112,942 | 105,957 | 112, |
| Ditto | ,034 | 60,034 | 46,872 | 46, |
| Ditto | ,189 | 74,408 | 67,221 | 60, |
| | ,674 | 405,226 | 370,066 | 381, |
| Fynone Broo | 016 | 142,324 | 127,350 | 112, |
| Mount Pleas | 909 | 44,887 | 40,986 | 37, |
| Di | 909 | 37,204 | 37,204 | 33, |
| | ,834 | 224,415 | 205,540 | 183, |
| Foxhole Bro | 319 | 45,025 | 39,931 | 30 |
| Cwmgelly B | ,050 | 240,149 | 247,710 | 106 |
| P | | | | |
| F | | | | |
| F | | | | |

LONDON:
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... WIDS AND THAT FROM BROOKS,
DRAINAGE.

... WILL BE PROPORTIONAL TO THE AVERAGE
BLUE LINE, & THAT OF THE LATTER,
THE RED LINE.