Report on the administration of the Rivers Pollution Prevention Acts / by the County Medical Officer.

COUNTY COUNCIL OF LANARK.

REPORT

ON THE

ADMINISTRATION OF THE RIVERS POLLUTION PREVENTION ACTS.

BY THE

COUNTY MEDICAL OFFICER.

1903.

GLASGOW
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To the Convener and Members of the Council of the County of Lanark.

My Lords and Gentlemen,

In accordance with the instructions of the County Council, I have prepared, and herewith submit, a Report setting forth the work done in the County under the Rivers Pollution Prevention Acts. This work has assumed such importance, has developed to such an extent, and the material at my disposal has become so voluminous, that the Report has grown to considerable dimensions. Without attempting to summarise the Report, permit me to make a few references.

It was not until October, 1895, that the County Council resolved to undertake the administration of the Rivers Pollution Prevention Acts, and in January, 1896, the first prosecutions were authorised. In June, 1900, two Inspectors, and, recently, a third, were appointed. In June, 1902, a Chemist was also appointed.

Five actions have been raised in Court for the prevention of pollution. In two of the cases the pollution arose from coal-dross washers, in two from ammonia works connected with blast furnaces, and in one from the sewage of a large town. In every case the result of the action has, so far, been satisfactory; in three proof was led, and in connection with these a few technical and several legal objections were raised. The interlocutors issued have in every case found the occurrence of pollution proven, and ordained suitable remedies. In one case the pollution was admitted, and improved preventive measures are to be provided at the instance of the Court. One case is still undecided, proof having been fixed for the 27th instant, although improved preventive measures have been adopted.

These results must be very gratifying to all those concerned with the administration of the Rivers Pollution Prevention Act of 1876, which is now generally treated with some respect, although

formerly there was perhaps no statute administered by the County Council treated with so much contempt. Prior to 1896, little, if any, action had been taken in Scotland under this statute, so that offenders were disposed to contest every point of procedure, and raise every objection the law might admit. The most careful consideration had, therefore, to be given to each case by those to whom the enforcement of the Acts had been entrusted, and the result has been the vindication of the law. The Rivers Pollution Prevention Acts remained, until a comparatively recent date, a dead letter. This seems to have been partly due to a very general belief that the provisions of these Acts were unable to accomplish the object intended, but the experience of this County has shown that this belief is unwarranted, and that the law is effective in compelling offenders to carry out preventive measures.

Offences are, according to statute, classified as "industrial" or as "sewage" pollutions, although the latter may contain large quantities of trade refuse. All the sources of pollution affecting the Clyde and its tributaries are so classified in Table W—see Appendix.

The industrial sources of pollution regularly inspected number about 100, and are classified according to the nature of the industry in Table B, page 10. Coal-dross washers prevail. The location of each source of pollution is indicated on Map I., page 45.

Means for the prevention of pollution have been provided in every instance, except at those works situated in Rutherglen Parish, and within the area of the Glasgow South-Side Sewage Scheme. The annual expenditure incurred by owners of public works in providing, maintaining, or using means for the prevention of pollution cannot readily be estimated, but at present the cost will considerably exceed £10,000 per annum.

The sources of sewage pollution are tabulated on page 74, and their location is indicated on Map II.

The City of Glasgow and four contiguous burghs within the area of Glasgow sewage schemes have a population of 929,253

(census 1901), besides immense industries. The completion of these great sewage schemes will be looked forward to with much interest.

The other seven burghs scattered throughout the County have a population of 151,278. There are also twenty-nine Special Drainage Districts throughout the three Wards of the County, with a total population of about 132,980.

Of the seven Burgh Authorities, two have provided means of sewage purification, while one is about to do so under an order of the Court. Eighteen of the Drainage Districts have some means of purification in operation or in course of construction. In some of these districts the sewage works are very efficient, but the cost of purification is very considerable, as seen by the fact that the drainage rate of assessment in one district is 1s. 3½d. and in another 1s. per £ of rental.

The means of purification adopted generally is the so-called septic tank and filters. The first installation of this nature was constructed at Uddingston, and opened about the close of the year 1899. A special investigation was made to determine the merits of this system of purification, and reports by the District Engineer and Medical Officer submitted to the Middle Ward District Committee will be found on pages 89 to 126. The results of the investigation were considered satisfactory.

The Clyde and its tributaries as a source of water supply and as affected by pollution are dealt with in Parts IV. and V. of the Report. The position of upland water supplies has been indicated on Map II. by the Engineers of the respective District Committees, to whom, and to others who have supplied me with information for this Report, my thanks are due.

I am,

MY LORDS AND GENTLEMEN,

Your obedient Servant,

JOHN T. WILSON,
County Medical Officer.

COUNTY BUILDINGS,
HAMILTON, 18*th April*, 1903.

STAFF.

County Medical Officer.

JOHN T. WILSON, M.D., D.P.H.

Assistant Medical Officers.

JOHN J. BUCHAN, M.B., D.P.H.

ALEX. LEDINGHAM, M.A., M.B., D.P.H.

Chemist.

WALTER K. CHESHIRE, B.Sc.

Inspectors.

ROBERT M'NAUGHTON.

CHARLES M'ARA.

FRANK M'ARTHUR.

I.—ADMINISTRATION.

Executive Authority.

In the earlier years of the new local government administration no action was taken by the County Council under the Rivers Pollution Prevention Acts, but the three District Committees dealt with any pollutions that were brought under their notice, and in the Middle Ward district the amount of work done was considerable. The experience gained in the first few years pointed to the expediency of having the Rivers Pollution Prevention Acts administered by the County Council as authorised by the Act of 1889, and at the statutory general meeting held on 10th October, 1895, the question of administration was brought before the Council in a report by the Public Health Committee, dated 4th September. This report is here quoted, as it sets forth the position of the County Council as regards administration:—

"It is enacted by the Local Government (Scotland) Act, 1889, Section 55 (1), that a County Council 'shall have power, in addition to any other authority, to enforce the provisions of the Rivers Pollution Prevention Act, 1876, subject to the restrictions in that Act contained in relation to so much of any stream as is situate within or passes through or by any part of their county, and for that purpose they shall have the same powers and duties as if they were a sanitary authority within the meaning of that Act, or any other authority having power to enforce the provisions of that Act, and the county were their district.'

"As the law stands at present, therefore, the Rivers Pollution Prevention Act may be enforced in Lanarkshire either by the County Council or by the District Committees, and, looking to the whole circumstances of the case, the committee are unanimously of opinion that it would be advantageous that the enforcement of the Act should be undertaken by the former.

"In arriving at their decision the committee have had in view that the River Clyde is common to all the districts, and, although it may be polluted in different degrees throughout these districts, in none of them is it free from pollution, and they have been influenced by a consideration of the desirableness of securing some common *modus operandi* for the abatement of pollution, and the employment of a common machinery over the whole area of the county, with the consequent lessening of the expense of the administration of the Act.

"It will be in the recollection of the Council that the principle of such a resolution as that now recommended has already been recognised in the determination to which the Council came with reference to this question in connection with local government amendment in the last two sessions of Parliament, when it was resolved, as the reports of the Council bear, that the Government should be asked to declare that the County Council should be the local authority for enforcing the Act.

"The committee accordingly suggest that the Council should resolve to undertake the enforcement of the Act so far as regards the pollution of the River Clyde and its tributaries, and that the District Committees should be recommended to refrain, to this extent, for the present from exercising their powers of prosecution under the Act. The committee would further recommend the Council to confer upon them full powers for carrying out the Act within the county as for and on behalf of the Council, and that any necessary expense to be incurred should be allocated to the public health rates in the several districts according to their respective valuations"

The meeting of County Council unanimously approved of the recommendations of the committee contained in this Report, which was adopted. It will also be noted that the executive authority thus constituted is in no way concerned with the management of special drainage districts, and therefore cannot be offenders under the Rivers Pollution Prevention Acts.

The permissive dual authority for the protection of rivers created by the Act of 1889 was never exercised in the County of Lanark. Proceedings in Court against offenders under the Rivers Pollution Prevention Acts were never taken by the District Committees, and in the brief summary here given of the administrative work done under the Acts it will not be necessary to refer to the districts separately.

Area of Administration.

Reference should be made to Map No. II. and the relative explanatory notes which are placed at page 74 of this report. The area of the Civil County of Lanark is given in the last Census (1901) as 562,821 acres, and includes the City of Glasgow, besides *eleven* other burghs. The area of the city and burghs is given as 21,473 acres. Therefore the area of the county, exclusive of Glasgow and other burghs, is 541,348 acres. The civil county includes practically the whole watershed of the Clyde to a point below Glasgow, and the old designation, Clydesdale, might appropriately be applied to the area of administration now under consideration.

The head-streams of the Clyde, viz., the Daer and the Potrail, are, after their union, joined by the little tributary from which the Clyde is said to take its name. Tradition alleges that the Clydes Burn was once a much larger stream than it is now, by having also the head-stream of Evan Water which joins the Annan, but this can hardly be discussed here. The more important tributaries of the Clyde are given in the following Table :—

TABLE A.—TRIBUTARIES OF THE CLYDE.

Name of Tributary.	Length in Miles.	Name of Tributary.	Length in Miles.
Potrail, ...	8	Douglas, ...	20
Daer, ...	10	Mouse, ...	13
Elvan, ...	8	Fiddler's Burn, ...	6
Midlock,...	5	Nethan, ...	15
Camps, ...	6	Jock's Burn, ...	5
Glengonnar, ...	7	Garrion Burn, ...	5
Duneaton, ...	17	Avon, ...	24
Roberton Burn,... ...	6	South Calder,... ...	11
Garf, ...	7	North Calder, ...	16
Culter, ...	8	Rotten Calder, ...	12
Medwyn, {North, South,} ...	21		

The Clyde, from the junction of the Daer and Potrail to the county boundary on the south side of the river below Glasgow and Govan, traverses a distance of about 75 miles.

Besides the streams above mentioned, there are a large number of water-courses which, from a rivers pollution prevention point of view, are of considerable importance. Indeed, that portion of the Clyde within the county most liable to pollution, viz., between Hamilton and Glasgow, is still a comparatively clean stream, capable of supporting fish life, whereas many of the small water-courses not named are so seriously polluted as to become offensive.

The area of jurisdiction has been considered a matter of great importance by those who allege that, for the successful administration of the Rivers Pollution Prevention Acts, it is necessary that

there should be but one authority for every watershed. It will, therefore, be desirable to refer specially to those streams liable to receive pollution from the County of Lanark, and which pass into or form mutual boundaries with neighbouring counties.

The River Almond rises in the east of Shotts Parish, where two head-streams unite, and are then known as the Almond, which enters the County of Linlithgow, near Harthill. The Almond also receives a tributary, known as the How Burn, which forms a portion of the boundary between the counties of Linlithgow and Lanark. Early in the administration of the County Council the pollution of the Almond was complained of. Inspections were made and reports submitted by the county officials. The How Burn and the Almond are at present liable to be polluted by coal-dross washings and soakage from waste heaps containing iron pyrites raised from the mines, but preventive measures have been enforced by the County Council under the statute, and only on one occasion during recent years has a complaint been received from Linlithgow county officials.

The Forrest Burn rises near the western extremity of Shotts Parish, and, flowing north-eastward for about seven miles, it enters Linlithgowshire. The water in the upper reaches of the burn has been impounded in a reservoir formed by the Bathgate District Committee of Linlithgow, while for some distance it forms the boundary between the two counties. This stream is only liable to pollution by coal-dross washings from a colliery, and on one occasion this pollution was complained of by the Bathgate District Authorities. An accidental pollution was discovered and remedied.

The Black Loch is situated partly in Lanarkshire and partly in Stirlingshire, and is liable to receive pollutions from Drumbow Colliery. No complaints of pollution have been received.

The Luggie Water forms part of the boundary between Lanarkshire and Dumbartonshire, and joins the river Kelvin,* which forms part of the boundary between Lanarkshire and Stirlingshire. Many of its head-streams rise in the northern portion of New Monkland Parish. Of these, the Cameron Burn is liable to be polluted by coal-dross washings from Darngavil Colliery. This pollution was on one occasion complained of by the Dumbartonshire Authorities, but preventive measures are in operation.

The White Cart forms a portion of the boundary with Renfrewshire for a considerable distance, and the only pollution it is liable

* The Kelvin is not liable, to any extent, to receive pollution from Lanarkshire, nor is the head-stream of the Stirlingshire Avon.

to receive from Lanarkshire is from that portion of Busby situated within East Kilbride Parish. The sewage from this area is satisfactorily dealt with by sewage purification works constructed in connection with the special drainage district recently formed there.

The Biggar Water rises near the northern boundary of Biggar Parish, and, after its junction with the Kilbucho Burn, flows into the Tweed. This water is liable to be polluted by sewage from the town of Biggar, but all the sewage is satisfactorily purified by irrigation.

There are one or two places where pollutions from the counties of Renfrew, Linlithgow, and Dumbarton affect streams forming boundaries with the County of Lanark. In only one instance, however, has a complaint been received. This complaint concerned a chemical work situated in the latter county, which discharged a coloured liquid into the Luggie Water.

From these facts it would appear that no difficulty need be experienced in dealing with pollutions in which more than one authority are interested, so long as there is an honest endeavour to administer the statutes.

EXECUTIVE OFFICERS.—The administration of the Rivers Pollution Prevention Acts by the County Council from October, 1895, to June, 1900, was carried on without specially appointed executive officials. The county medical officer, with the assistance of the sanitary inspectors, made the necessary inspections, and reported the results to the county clerk. Some assistance was for a short time obtained from the constabulary, arrangements having been made whereby any pollutions observed might be reported through the chief constable to the medical officer.

The want of systematic inspection became increasingly felt, and a report, of date 24th January, 1900, was submitted by the medical officer, suggesting that two inspectors should be appointed for this purpose, and for the purposes of the Sale of Food and Drugs Acts. At a meeting held on 25th April, 1900, the Public Health Committee resolved that the appointment of inspectors for these purposes be made without further delay.

Two *inspectors* were appointed, and entered upon their duties in June, 1900.* Since then sources of pollution have been inspected and the results recorded. These inspections brought to light a large number of trade pollutions which as a rule were easily detected. In a few cases, however, there was evidence of pollution taking place at hours which made detection difficult, and

* On 1st April, 1903, the Public Health Committee authorised the appointment of another inspector.

this, in one case, led to an all-night inspection. Occasional pollutions still take place on Saturday afternoons and Sundays, necessitating special inspections on these days. It may be stated that every form of pollution has now been reported to and carefully considered by the Public Health Committee of the County Council. The work done in connection with *industrial pollutions* is summarised in the following Table :—

TABLE B.—SHOWING THE VARIOUS SOURCES OF INDUSTRIAL POLLUTIONS, THE INSPECTIONS MADE, AND THE POLLUTIONS DETECTED DURING THE LATTER HALF OF THE YEAR 1900 AND THE YEARS 1901 AND 1902.

SOURCES OF POLLUTION.				INSPECTIONS.			SAMPLES.			POLLUTIONS DETECTED.		
Industries.	Number in each Year.			Number in each Year.			Number in each Year.			Number in each Year.		
	1900.	1901.	1902.	1900.	1901.	1902.	1900.	1901.	1902.	1900.	1901.	1902.
Coal-dross Washers, ...	62	64	68	278	446	444	175	439	468	70	119	143
Ammonia Works, ...	14	16	16	32	76	50	30	57	85	7	38	23
Paper Mills, ...	4	4	4	13	15	14	10	36	31	5	11	8
Print, Dye Works, &c.,	7	7	7	8	29	7	14	10	4	4	3	...
Oil Works, ...	1	1	1	...	1	...	...	2	...	...	...	...
Chemical Works, ...	1	1	1	...	1	...	...	...	...	...	...	...
Distilleries and Breweries,	3	3	3	5	1	...	4	1	...	1	...	...
* TOTAL, ...	92	96	100	336	569	515	233	545	588	87	171	174

The inspections made and samples taken in connection with *sewage pollutions* were as follows :—

In the year 1900—38 inspections, and 78 samples.
" " 1901—48 " " 57 "
" " 1902—101 " " 169 "

During the same period the Clyde from near its source to a point below Glasgow, and its more important tributaries, have been inspected, and 79 samples taken for analysis. The total number of samples taken by the inspectors during the two and a half years is thus 1,749.

Chemist.—The analytical work was at first carried out by the assistant medical officers in the laboratory of the Public Health

* The Lead and Silver Mines at Leadhills are not included. They were twice inspected during the year 1902, and six samples taken.

Department but owing to increase in the number of samples taken, and to other causes, it was found desirable to appoint a chemist who would devote his whole time to laboratory work. Permission was asked and granted on 30th April, 1902, to make such an appointment, which was done—the chemist joining the staff on 24th June.

Offices, including chemical and bacteriological laboratories, have been provided for the whole staff in the recent additions to the County Buildings at Hamilton, and were occupied on 25th March, 1902.

GENERAL PROCEDURE.—The inspectors report daily to the medical officer the results of their visits, who arranges with the chemist for the analyses of such samples as may be necessary to substantiate a complaint. The work done by the inspectors and the chemist is summarised in a monthly report, printed and issued to the Public Health Committee. The greater portion of the routine work has related to the most serious industrial or trade pollutions, but sewage pollutions have by no means been neglected. All pollutions of a serious nature are reported to the county clerk, who communicates with the offenders, with, in most cases, satisfactory results. The amount of good work done in this way has been very considerable. All cases where satisfactory results are not attained by this procedure are specially brought before the Public Health Committee, when, if necessary, legal proceedings are authorised. In adjudicating upon such cases the committee have had regard to the number of offences detected, the nature and effect of the pollution, the inadequacy of the structural arrangements provided for preventing pollution, and the careless or improper management, or misuse of these.

In taking legal proceedings under Part III. of the Act the first step is an application to the Secretary for Scotland for his consent under Section 6 of the Statute. Altogether fifteen applications have been made, and in no case has this consent been refused. On the obtaining of such consent there is served upon the offenders a two months' notice, as required by Section 13 of the Act. The clerk has general authority from the committee to make application to the Secretary for Scotland, and to serve the statutory notice upon offenders in all cases where, in consultation with the medical officer, he may consider such action expedient.

In obtaining and preparing the information necessary for proceedings in Court, the medical officer or an assistant inspects the *locus* along with the inspectors; and, while taking samples for

analysis by the chemist, duplicates are generally obtained and examined by the public analyst. Informations, based upon these inspections and analyses having been prepared and submitted to the county clerk, the case is put into the hands of the law agents, and up to the present every action raised has been successful though the court procedure has been tedious.

The only exception to these general remarks worthy of mention concerns certain public works situated in Rutherglen parish. Of these, five were reported as causing considerable pollution of the Clyde, the owners being communicated with in 1898 by the county clerk. About the same time, however, the Glasgow Sewage Act of 1898 was before Parliament, and, as it provided for the inclusion of all these works in the Glasgow South-side Scheme, no further action was taken.

As the responsibility for sewage pollutions of any extent rests with the respective local authorities—viz., the Burgh Commissioners and Town Councils in burgh areas, and the District Committees where special drainage districts have been formed within their areas—and as the burgh authorities were by far the most serious offenders, it was deemed advisable to hold a conference with burgh representatives. This conference was held on 22nd September, 1896, when there were present representatives from all the Burghs—Airdrie, Coatbridge, Hamilton, Lanark, Motherwell, Rutherglen, and Wishaw. Biggar was not invited as the drainage there is to the Tweed. An account of the conference is given in a report to the Public Health Committee, dated 30th September, from which the following quotation is made :—

"Conference with the Burgh Representatives.—Having regard to the relations in which the County Council stand to the burghs in the county, and to the common interest which they all have, county and burghs alike, in the purifying of the Clyde, the committee considered it right to put themselves in communication with the authorities of those burghs lying in the Clyde basin above Glasgow. They invited them to a conference on the subject, which was held at Hamilton on 22nd September. It was largely attended, and a friendly and interesting discussion was the result. A common admission was made of the importance of the subject, and of the necessity for adopting measures for purifying the river and its tributaries. The representatives of the burghs generally admitted their legal liabilities in the matter, while the committee explained the position of the County Council and their powers under the Act for its enforcement.

"As indicating the position taken by the committee in bringing the matter before the burgh representatives, they may quote some of the words

used by the Convener of the County (the late Sir Windham Anstruther), who was appointed by the conference to preside. He said—

"'I am obliged to you, gentlemen, for the compliment you have paid me in electing me chairman of this conference. The subject we have met to consider is an important one, and I say it is an important one, because, if it has done nothing else, it has overthrown an idea that we have long had, that rivers had been wisely appointed by Providence as the natural vehicles for conveying to the sea sewage and all noxious things injurious to mankind. Modern ideas, however, have done away with that idea, and the object of the County Council in asking you to meet us to-day is that in a friendly conference, and not a formal one, we might come to some understanding as to how to avoid the pollution of the streams in the County of Lanark.

"'As representing the County Council authority, having power in this matter over burghs as well as rural districts, we do not propose to lay down any hard and fast lines. We want to give you full power; we have no desire to dictate to you what should be done; but we think the time has come when it is necessary that something should be done to stay the pollution of the Clyde. The County Council are the protectors of the river, and they are in the happy position of not being offenders against the Act, the provisions of which they can thus enforce without fear or favour. We are therefore able to take a most impartial view of the subject, and I must point out to you that, according to statistics which I have before me, the burghs in the county are accountable for no less a population than 127,000, which is rapidly increasing. Now, in these burghs there are no means taken for the purification of the sewage, excepting in the case of Wishaw. The County Council are the supreme authority in this matter, and we admit at once that the district committees are also offenders under the Act; but it is utterly useless for the rural authorities to commence operations until the burghs agree to do the same.

"'I would have you to bear in mind also that Glasgow is now doing the best it can for the purification of the Clyde, and the city authorities may turn round to the county and say, very naturally, that there is little use of their trying to purify the Clyde while you continue to send down the sewage of 127,000 people. The law is clear that no one is entitled to free his own ground of a nuisance and make his neighbour bear the ill consequences of it.

"'The County Council are willing to help you as far as possible, and it is for you to indicate to us if you are prepared, within a reasonable time, to do anything towards attaining the object in view. I leave the matter open to discussion, and I hope you will clearly understand that it is in a very friendly spirit that you have been asked to meet the county authorities here, and I trust you will try and suggest something which may meet the difficulties, and do away with the river pollution now existing.

"'It is not for us to say what schemes of purification you should adopt. You are the best judges of what should be done, and we wish you

to have a free hand in that matter. It is more to excite your dormant attention on this subject that we have asked you to meet us to-day, in the hope that you will look upon this as one of the most serious questions of the hour, and one that must at once be dealt with.'

"In closing a report, the subject of which would have justified much more time and elaboration, the committee cannot but again refer to the exceptionally favourable position in which the County Council stand for carrying on the work which they have begun. They themselves are not, and cannot be, offenders against the Act of 1876. They are thus safe from the *tu quoque* argument not unfrequently available between communities, as between individuals, when one of them tries to put matters right.

"A state of things has been growing up during many years which cannot be rectified all at once. Patience, time, thought, and money must be expended before the necessary remedies are found and applied. But a judicious use of these will be rewarded by the purification of the streams of the county, and notably of the river which at present is being so grievously polluted."

After six weeks had elapsed the county clerk again communicated with the respective burgh authorities above mentioned, except Wishaw, and subsequently with the district committees. The replies received from the latter were considered satisfactory, whereas the replies received from the burgh authorities were in most cases not so. The Public Health Committee, with a strong desire to avoid proceedings in court if at all possible, allowed two years to pass, issuing reminders and warnings, but the only advance made was by the Burgh of Rutherglen joining with the Lower Ward District of the County in the Glasgow Southern Sewage Scheme as provided for by the Glasgow Sewage Act of 1898. It became clear that the large burghs of Airdrie, Coatbridge, Hamilton, and Motherwell, were not prepared to move in the matter without compulsion, so that the County Council were obliged to take legal proceedings to enforce the provisions of the Rivers Pollution Prevention Acts, and on 11th January, 1899, the county clerk was instructed to raise an action against the Burgh of Motherwell.

Inspections of pollutions from the other offending burghs during the year 1902 showed that the conditions were much the same as when first reported—that is, no means have been provided to purify the sewage. Informations in each case were therefore lodged with the county clerk, who has again been in communication with the authorities concerned.

I now propose to give a few brief notes of the more important cases in which the County Council found it necessary to take action, and append a record of the *court proceedings*.

Actions concerning Pollutions by Coal-Dross Washings.

In January, 1896, the committee resolved that, subject to the consent of the Secretary for Scotland, proceedings should be instituted against the proprietors of seven collieries for causing serious pollutions by coal-dross washing operations. Inspection of the seven collieries was made by an inspector (Mr. Curphey), appointed by the Secretary for Scotland. When this inspector's report was submitted to his lordship, correspondence with the offenders ensued, which resulted in the necessary remedial measures being carried out without recourse to proceedings in Court. Mention might, however, be made of one of the cases, viz., Bankend Colliery, where the pollution caused gave rise to an action by a riparian proprietor.

Bankend Colliery, situated at Coalburn, in Lesmahagow Parish, was reported on 5th August, 1896, to be still polluting, and the clerk was instructed to inform the owners that unless proper steps were taken within four weeks to remedy the pollution proceedings would be instituted against them. At the end of that period remedial measures were in course of being provided, and by 13th January, 1897, they were said to be completed. About this date, however, an action was raised by the proprietor of a neighbouring estate through which the stream affected flows. This action at common law involved the Council's officials as witnesses in court. The action was successful, but the colliery shortly thereafter was shut down.

Tannochside Colliery.—In connection with a list of offenders submitted to a meeting of committee held on 17th March, 1897, the clerk was instructed to apply to the Secretary for Scotland for his consent to legal proceedings being taken against the owners of this colliery. An inspection was made by the inspector under the statute, and correspondence ensued, with the result that, on 2nd March, 1898, the clerk reported that his lordship's consent to institute proceedings had been obtained. A report, however, was submitted by the medical officer showing that additional purification works had recently been erected by the offenders, and under the circumstances the committee agreed that proceedings should be stayed meantime. This colliery shortly afterwards changed ownership, and no further serious pollution was detected. The new owners provided a new washery, with silt recovery and other modern appliances for the prevention of pollution. The drainage from this colliery affected the North Calder.

Westburn and Gateside Collieries.—In May, 1899, the clerk reported that he had applied to the Secretary for Scotland for his consent to proceedings being taken against the owners of these collieries, which are situated in Cambuslang Parish. Inspection was, as usual, made by the inspector, and in December the clerk informed the committee that he had received his lordship's consent to the institution of proceedings, on condition that measures were at once adopted for preventing the pollution of the stream by sewage. At Gateside Colliery remedial measures were carried out, but at Westburn Colliery pollution still continues. Owing to the condition attached to the Secretary for Scotland's sanction the clerk again communicated with his lordship, explaining that the County Council were not in any way responsible for the pollution of the stream by sewage, and obtained his sanction, without qualification, to institute legal proceedings against the owners of Westburn Colliery, which drains into the Gateside Burn, thence to the Clyde. The water, as raised from the mine, contains about 100 grains per gallon of suspended solids, consisting chiefly of fireclay. The water, after passing through the washery, contains over 1,000 grains per gallon of suspended solids. The washing plant is of old construction, has no proper means of silt recovery, and the water is not used over again. The settling ponds, being very inadequate in area and construction, allow the washings to escape before proper settlement has taken place, so that the effluent discharged into the stream is always more or less polluted with suspended solids taken up during washing operations. Legal proceedings were instituted.

Stane and Kepplehill Collieries.—In connection with these two collieries, situated in Cambusnethan Parish, but near Shotts, serious pollutions were complained of from time to time. Ultimately, on 6th October, 1900, application was made to the Secretary for Scotland, and sanction to institute proceedings granted on 11th March, 1901. The drainage from these collieries finds its way into the Blind Burn, thence to the South Calder. The washing plant is of old construction, is not provided with a silt recovery apparatus, and the water is not used over again. The water as raised from the mine is used in the washery, and is almost entirely free from suspended solids. The effluent, however, as discharged from these collieries, as sampled at various times, has contained from 65 to 1,355 grains per gallon of suspended solids. Legal proceedings were instituted in these cases also.

Actions concerning Pollutions by "Spent Liquor" from Ammonia Works.

Clyde Iron Works.—As far back as May, 1893, complaints were received of pollution of the Clyde by "spent liquor" from these works, and were considered by the Middle Ward District Committee. About January, 1896, a very serious pollution was reported to the county committee. So seriously was the Clyde affected that tar oils could be traced on the surface of the water for many hundred yards, and several dead fish were found by the side of the river. The county clerk communicated with the owners threatening legal proceedings unless remedial measures were carried out, and application was also made to the Secretary for Scotland for his consent thereto. The usual inspection and correspondence followed, but it was not until about January, 1897, that the Secretary for Scotland intimated to the offenders that a period of six months would be granted for the consideration and adoption of means to prevent pollution. Meanwhile the pollution had been considerably abated. At the end of the six months' period the Secretary for Scotland was again communicated with, and it was ascertained that remedial measures were being provided. On 1st September, 1897, the medical officer reported that an evaporating plant was in operation, and that the pollution had ceased. Some six months thereafter pollution was again detected, but the company on being written to did not admit the pollution.

After the appointment of inspectors, and towards the end of 1900, serious pollution was again found to be taking place. On visiting the works the evaporating plant, specially constructed to obviate pollution, was found standing idle, and had the appearance of having been out of use for some time. It was stated that the liquor was evaporated by being poured on the hot slag, but at the time of visit this was not being done. Consequent upon this visit, a lengthy correspondence ensued without any satisfactory result. The consent of the Secretary for Scotland to take proceedings was again asked for, and, after the usual inspection, obtained on 31st May, 1901. As a last resort, an interview between the company's officials and the medical officer and depute county clerk was held. At this interview pollution was still found to be taking place, but was not admitted by the offenders' representatives, and proceedings in court were unavoidable.

At *Carnbroe Iron Works* serious pollutions, affecting the North Calder, were detected from time to time, and first reported to the committee in October, 1898. As the pollutions were denied by the

company, application was made in May, 1899, to the Secretary for Scotland for his consent, which was granted, to take proceedings in court. The pollutions detected were evidently intermittent, and only occasionally of a very serious character, when the effect of the pollution could be detected for several miles below the outfall from the works. Legal proceedings were instituted.

At *Coltness Iron Works* intermittent pollution by spent liquor, affecting the Auchter Water and South Calder, was detected in 1898, and, on representations being made to the owners of the works, a specially constructed plant was provided for evaporating the liquor.

At *Shotts Iron Works* also intermittent pollution was detected, and further preventive measures have since been adopted.

Gas-works.—The recent introduction of sulphate of ammonia plant at several of the gas-works in the county has given rise, in some instances, to pollution. Thus the Uddingston and Bothwell Gas-light Company discharged the "spent liquor" into a sewer connecting with the Uddingston Sewage Purification Works, and thereby caused considerable trouble. The company were communicated with, and they at once took steps to obviate the pollution by evaporating the liquor on the live coke as it is drawn from the retorts. At Hamilton Gas-works, in connection with the introduction of ammonia plant, a representation was made by the clerk, and similar precautions were adopted.

Tarbrax Oil Works.—Pollutions of a serious nature were complained of in 1897 by a sheep farmer, who alleged that several of his sheep had died through drinking from a stream which flowed through his lands, and which was polluted by "spent liquor" discharged from these works. After some correspondence, application was made to the Secretary for Scotland, and his consent obtained to the institution of proceedings. In 1898 an action was raised against the offenders—The Caledonian Mineral Oil Company, Limited—which was then in liquidation. The Court, however, decided that the company, being an English one, the consent of the High Court was necessary to legal proceedings being taken. The consent of the High Court was therefore obtained, but no further action was necessary. A new company had taken over the works, and, in consequence of the previous action by the County Council, remedial measures were carried out which have so far prevented further serious pollution.

Actions concerning Pollutions by Paper Mills and Print Works.

The only works of this nature which have given rise to proceedings are situated on the upper reaches of the North Calder. Complaints against these works were evidently made prior to the new period of local government, as is shown by a report of inspections made on the 24th and 30th May, 1889, by Alfred E. Fletcher, the then inspector for Scotland under the Rivers Pollution Prevention Act. Complaints were also made to the Middle Ward District Committee in 1892. During this and the two subsequent years the matter was frequently under consideration, and led to the service of notices under the statute, and to application being made to the Secretary for Scotland for his consent to proceedings in Court. This led to some remedial measures being carried out. The action taken since 1895 is briefly as follows :—

Glengowan Print Works.—The complaints and inspections made have shown that pollution occasionally occurs, but the representations made by the county clerk have led to further remedial measures being adopted.

Caldercruix Paper Mills.—The same remarks apply to these works, where extensive settling-ponds have been provided.

Moffat Paper Mills.—The pollutions detected from these works have been of a more serious character, and at one time it almost seemed as if legal proceedings would be necessary. Satisfactory remedial measures, however, have been partly carried out, and it is hoped will soon be completed.

Actions concerning Pollutions by Sewage.

The only case which falls to be recorded under this heading is that against the Commissioners of the Burgh of Motherwell, which at the census of 1901 had a population of over 30,000, its growth during the past 15 years having been very rapid. Situated on a ridge, the ground slopes on the north to the South Calder Water, and on the south to the River Clyde. The northern sewage outfalls were six in number, and the southern outfalls five in number. Some irrigation at two of the outfalls was occasionally carried out, as it suited the farmer, but practically no sewage purification was attempted. Serious nuisances arose in connection with two of the southern outfalls. Thus, the Sow Burn receives an 18-inch sewer, making the burn at all times most offensive to the eye, and causing it during summer and autumn weather to give off offensive odours, which were complained of by pedestrians and

by the inmates of the large isolation hospital erected by the Middle Ward District Committee, past the north-west boundary of which the burn flows. The outfall which discharges at the east end of the plantation known as Airbles Glen, where it flows into the Muckle Burn, thence to the Clyde, is also very offensive to the occupiers of miners' houses situated close by; and where the stream passes underneath an avenue to Dalzell House, it may also be regarded as a nuisance. Samples were taken for analysis at twelve different points, and the results showed that considerable pollution was taking place, but, owing to the wide distribution of the outfalls on the Calder and on the Clyde, the effect upon these streams was not very marked, and it is important to note that, although the complaint charges the offenders with the pollution of six different streams, including the River Clyde, the interlocutor issued by Sheriff Davidson, dated 5th April, 1900, does not include the Clyde among the streams polluted—see the latter part of note to said interlocutor. The extent of the pollution may be gathered from the fact that about a million gallons of sewage are discharged daily from the burgh, and from the facts in the subjoined table, in which the analysis of the water supplied to the town is compared with the average analysis of the sewage samples taken. It must also be borne in mind that these samples were taken at a time of the year (February) when sewage is largely diluted with rain and surface water :—

TABLE C.—ANALYSIS OF THE WATER SUPPLIED TO THE BURGH OF MOTHERWELL AND OF THE SEWAGE AT THE OUTFALLS.

The chemical results are stated in grains per gallon.

MOTHERWELL.	Total Solids.	Chlorine as Chloride of Sodium.	Free or Saline Ammonia.	Albuminoid or Organic Ammonia.	Oxygen required to oxidise the organic matter.
Water Supply, - - -	17·0	2·14	0·000	0·0138	0·609
Average of Sewage Samples,	53·2	5·91	1·72	0·61	6·04

The record of court proceedings shows that, on 29th July, 1902, a report and relative drawings, prepared by Mr. Carter, C.E., on the remit from the sheriff were received. This report provides for the interception of all the southern outfalls, and the treatment of the sewage at one point. The northern outfalls are dealt with at two different points. The purification works were to consist of septic tanks and filters, the cost of the proposed scheme being estimated at £34,000, or a little over £1 per head of population.

Record of the Court Proceedings, including the sheriffs' interlocutors and notes, in the five cases in which the County Council were obliged to appeal to the Court to enforce compliance with the provisions of the Rivers Pollution Prevention Acts. For this information I am indebted to the county clerk and the law agents. It will be found both interesting and instructive, as showing the policy usually adopted by the respondents, who managed, in some cases, to postpone the ultimate judgment of the Court, but it is satisfactory to be able to state that the County Council were in every case successful.

(1) THE BURGH OF MOTHERWELL.

1899.

May 19.—Petition presented.
June 2.—Case continued till 6th for defences.
„ 6.—Defences lodged and case continued till 13th instant for parties to adjust.
„ 13.—Case continued till 20th, on Defenders' motion.
„ 20.—Record closed, and debate fixed for 10th July.
July 10.—Debate—Avizandum made.
Aug. 31.—Sheriff Davidson—Interlocutor allowing proof:—"Having heard Counsel, and made avizandum, repels first, second, third, fourth, and sixth pleas-in-law for the Defenders, and the additional plea-in-law for the Pursuers, allows both parties a proof of their averments, and sends the case to the Roll of Friday, 15th September next, to fix a diet.

"(Sgd.) MARK GEORGE DAVIDSON.

"NOTE.—With the exception of the plea that all parties are not called, the arguments adduced for the defenders all resolve themselves into this, that the Rivers Pollution Act, 1876, is one to be put in force only at the discretion of the Court, and that in the present instance its application is opposed to public policy. I do not think the plea of all parties not called is tenable. If it were a good defence, all that it would be necessary for the defenders to do is to show that some one else, it might be a single individual, discharges sewage into the Clyde as well as themselves. It appears to me, therefore, that the second plea-in-law for the defenders must be repelled. The pursuers do not, I understand, press for this in the meantime; but, if the plea is left standing, it will open the door to a very large proof of circumstances which, in my view, are irrelevant to the complaint.

"As regards the main defence, I am of opinion that it is not well founded. It is true that, in Section 10 of the Act, it is said that the County Court may require any person to abstain from commission of an offence under the Statute, but I take it that, if an offence is proved, the County Court has no option but to apply the Act. It is argued, on behalf of the defenders, that the best available means of disposing of their sewage may not be within their option, and that they may have, as the result of this application, to go to Parliament for further powers. I am afraid this plea will not avail them in view of the express terms of the Act of 1876. At the time that Act was passed public bodies, such as the defenders, had

Burgh of Motherwell.

less power both for acquiring land and for the disposal of sewage than they have now, and it is not seriously disputed that such bodies are liable to be brought into Court and to have the Act enforced against them. It appears to me that the possibility of difficulties in obeying an order under this Statute, assuming such an order to be ultimately made, are foreign to the consideration of an application founded on averments that the Act is being infringed. The defenders further plead that no complete scheme for the purification of the River Clyde can be achieved unless by the joint-action of the various local bodies interested, the parties to this action, and the Burghs of Hamilton, Coatbridge, &c. Even assuming this to be true, I do not see how it can be a bar to a complaint under the Act of 1876. Nor do I think that the fact that a Royal Commission on the disposal of sewage is at present sitting is in any way a reason why the Court should refuse or delay to enforce the Act.—(Intd.) M.G.D."

1899.

Sept. 7.—Defenders appeal to the Second Division of the Court of Session. This appeal was subsequently abandoned.

Oct. 17.—*Interlocutor* dismissing appeal.

,, 31.—Case before Sheriff Davidson. Proof fixed for 11th December.

Dec. 1.—Diet superseded, and 15th January fixed in lieu thereof, on Defenders' motion.

1900.

Jan. 15.—Proof led and diet adjourned till 26th February for taking remainder of proof.

Feb. 26.—Proof closed, and parties having been heard, avizandum made.

April 5.—Interlocutor by Sheriff Davidson:—"Having heard parties' Counsel, and made avizandum, finds that the Defenders have contravened the Rivers Pollution Act, 1876, S. 3, inasmuch as they have knowingly permitted sewage matter to flow into the streams known as the South Calder Water, Sow Burn, the Muckle Burn, Gilly's Burn, and the Todhole Burn, and continues the case for further procedure.

"(Sgd.) MARK GEORGE DAVIDSON.

"NOTE.—The Rivers Pollution Act, under which this application is made, states broadly that any person who causes to fall or flow, or knowingly permits to flow, into any stream any liquid or solid sewage matter is a contravener of the Act. In subsequent sections there are various qualifications of this provision, of two of which the defenders argue that they are entitled to take advantage. In another part of Section 3 it is provided that no person shall be deemed to have contravened the Act if he shows that the channels used for sewage, having been used for sewage at the time of the passing of the Act, he is using the best practicable and available means to render the sewage harmless. The defenders are not treating the sewage, assuming that it is suffered to fall or flow into these streams at all. They send a portion of it—not apparently a large portion—on to two sewage farms, and beyond that they do nothing. Section 20 defines 'stream,' and the defenders argue that the various channels named do not come under the definition. But they are all water-courses, and the only water-courses excepted from the definition are those 'at the passing of the Act mainly used as sewers, and emptying directly into the sea.' Of course none of the water-courses mentioned in this petition, except

the Clyde, which I have so far adverted to, satisfy the latter of these requirements. Having got so far, the question whether the burgh of Motherwell permits sewage to flow into these streams admits of only one possible answer. The defenders, however, refer to the cases of Dorking (20 Ch., Div. 595) and Glossop (12 Ch., Div. 102), where it was held that a sanitary authority was not in fault for merely permitting existing sewers to be used by the inhabitants as they had been before the passing of the Act. But the case of the West Riding of Yorkshire *v.* Holmfirth (2 Q.B., 842, 1894) seems to me to be more in point than either of these, and it is a later authority. The defenders have acted precisely as the Holmfirth Sanitary Authority did. They have adopted and altered and made complete a system of drainage existing prior to 1876, whereby the sewage of the town went into these streams. As to this, Mr. M'Callum's evidence is instructive. In the Holmfirth case it was laid down that it was not necessary to show that the defenders have increased the quantity of sewage, or even that they have done nothing at all, if they might have prevented it from flowing into the stream. It does appear to me that the learned judges who decided that case felt some little difficulty as to the cases of Dorking and Glossop. Lord Justice Lindley observed that the power of the Court is discretionary, and that it will not grant injunctions to compel people to do what they cannot do, and that is really one part of the decisions in the Glossop and Dorking cases; while a reference to the reports of these cases certainly does not suggest that it was a very important part. However that may be, I cannot really distinguish between the Holmfirth case and that of Motherwell. The defenders further urge that the Court should use its discretionary power, quoting from Lord Justice Lindley, and exempt them from the operation of the Act, because they might go to great expense in treating the sewage of Motherwell and then find their money thrown away, if experts declared that they were not using the best practicable and available means. I have some sympathy with this contention, but I would point out that under Section 3 they are entitled to get a certificate from the Local Government Board, while under Section 10 they may at this stage move the Court to remit to experts to report on the best means, and such a report, with the authority of the Court, would, I should think, be a sufficient protection from further attacks under the Act. But it is scarcely necessary to observe that to admit a plea of this kind would be to hang up the Act altogether. I cannot say I think the defenders have made anything of their charge against the pursuers that they contribute to the pollution of these streams, so as to bar themselves from making this application; and it only remains to notice the one point on which I find myself unable to give the pursuers the finding they desire. It is, of course, true that all the sewage matter sent from Motherwell into these streams finds its way ultimately into the River Clyde. But, whether from exposure to air and light, or because of the dispersal of matter by the large body of water in the river, it seems from the evidence that the effect on the Clyde is not such as to be appreciable. But, apart from that, I think that, as the defenders do not allow any matter to fall into the Clyde except through these streams, and I have already found that they have contravened the Act in regard to them, any similar finding as to the Clyde must refer to the same sewage pollution as to which a contravention has already been proved, and is therefore incompetent. The pursuers asked, on the assumption that I found in their favour, that I should merely issue a finding to that effect, leaving further proceedings to be determined later. I think that is reasonable, and I have done so.—(Intd.) M.G.D."

Burgh of Motherwell.

Burgh of Motherwell.

1900.

April 17.—Defenders appeal to the Sheriff-Principal.
Nov. 23.—Parties appointed to debate on appeal on 5th December.
Dec. 5.—Debate.
„ 11.—Interlocutor by Sheriff Berry:—"Having heard Counsel for the parties, finds that the appeal is incompetent, therefore dismisses the same, and decerns, and remits to the Sheriff-Substitute for further procedure.

"(Sgd.) ROBERT BERRY.

"NOTE.—I understand that it is not disputed that the competency of this appeal depends on the provision of the Sheriff Court Act, 1876. In view of Section 27 of that Act, I am of opinion that the appeal is not competent. The interlocutor of the Sheriff-Substitute does not fall under any of the categories of judgments or interlocutors against which an appeal is allowed by the section. I was asked to give the expenses of the appeal to the respondents. They are, no doubt, entitled to expenses, but it seems to me unnecessary to give an award in their favour at this stage of the proceedings. Whatever may be the final result of the case, the respondents will be entitled to the expenses of this abortive appeal. Having regard to the importance of the case to the community, I think it is a fit case for the employment of counsel.—(Intd.) R.B."

1901.

March 1.—Remit made by Sheriff Davidson to Mr. Carter.
„ 6.—Interlocutor:—"Having heard parties' procurators, repels the defences, remits to Mr. William Allan Carter, C.E., 5 St. Andrew's Square, Edinburgh, to examine the South Calder Water, Sow Burn, Muckle Burn, Gilly's Burn, and the Todhole Burn, hear parties, report on the best practicable and available means of preventing the fall or flow of the sewage matter referred to into these burns, or of rendering harmless the said sewage matter, and the nature and cost of the work and apparatus required. Certifies the witnesses Dr. Robb, John Clark, Charles Puller Hogg, William Liston Douglass, Dr. Tatlock, Dr. King, W. R. Copland, and R. T. Thomson. Finds the Pursuers entitled to expenses, and decerns.

"(Sgd.) MARK GEORGE DAVIDSON.

"NOTE.—The Sheriff-Substitute has given a finding of expenses at this stage that parties may appeal as they desire.—(Intd.) M.G.D."

1901.

Mar. 19.—Defenders appeal to Sheriff-Principal.
April 25.—Parties appointed to debate on 20th May.
May 20.—Case before Sheriff Berry, when no appearance for Defenders, and appeal dismissed, with expenses.
June 1.—Interlocutor:—"On the motion of Counsel for Respondents (the Pursuers), there having been no appearance by or for the Appellants at the diet for hearing parties on the appeal, dismisses the appeal, finds the Appellants liable in the expenses of this appeal, and also of the abortive appeal dealt

with in the interlocutor of 11th December last, sanctions the employment of Counsel in the appeals, and remits to the Sheriff-Substitute for further procedure. *Burgh of Motherwell.*

"(Sgd.) ROBERT BERRY."

June 28.—Defenders appeal to First Division of the Court of Session.
July 3.—Interlocutor dispensing with printing notes of evidence.
„ 19.—Interlocutor remitting to Sheriff Berry to report on procedure in his Court in dealing with appeals.
Oct. 4.—Sheriff Berry's Report transmitted to Edinburgh.
Nov. 19.—Discussion in Inner House, when appeal was dismissed, with expenses.
Dec. 17.—Inspection of outfalls by Referee.

1902.

Jan. 29.—Motion for approval of employment of Counsel enrolled before Sheriff Davidson.
„ 31.—Case continued till 4th February for discussion.
Feb. 4.—Motion granted.
„ 6.—Process sent to Mr. Carter.
July 29.—Mr. Carter's Report and relative Drawings received.
Aug. 12.—Case enrolled for 15th August.
„ 15.—Report and Drawings lodged in process. Case continued till 3rd October.
Oct. 3.—Objections to Report by Defenders lodged. Case continued till 14th.

The report proposed to collect the sewage outfalls at three different points—two on the South Calder and one on the Clyde. Sewage purification works, consisting of tanks and filters, were proposed to be erected at these three points. The objections of the defenders referred mainly to the difficulty of acquiring ground for purification works on the sites selected by Mr. Carter.

Oct. 14.—Interlocutor appointing Mr. Carter to report on objections:—"Allows the objections to Mr. Carter's report to be received and to Form No. 33 of Process. Remits of new to Mr. Carter, and appoints him to report whether or not the suggestions made by defenders in said objections are or are not reasonable, and to say whether, in his opinion, any or what effect should be given to them, and continues to a diet to be afterward fixed.

"(Sgd.) MARK GEORGE DAVIDSON."

„ 17.—Objections sent to Mr. Carter.

1903.

Feb. 12.—Mr. Carter's report on objections received, as follows:—"In obedience to your lordship's remit as contained in the above quoted interlocutor of 14th October, 1902, I carefully considered the objections lodged by the defenders to my scheme, as described in my report to your lordship of 24th July, 1902.

"After considering the whole of these objections I came to the conclusion that I could not, with justice to the parties and to myself, reply to them without further and more specific information than was contained in the objections as stated,

Burgh of Motherwell. **1903.** Feb. 12.

and, with the view of getting such information, I arranged for an interview with the Agent for the Defenders.

"At this interview we discussed *seriatim* the whole of the objections, and I showed him that none of them were insuperable, and that most of them were of very little account as affecting the general principle of the scheme which I had submitted. Moreover, I pointed out that any of those objections—the subject of which might constitute a source of difficulty when coming to the practical arrangements for carrying out the work—could be met by modifications of detail, such as would not prejudicially affect the scheme as a whole.

"Having very fully discussed the matter, the agent for the defenders suggested my again going over the ground, and thereafter probably meeting the members of the Drainage Committee, who could give me more information on certain of the objections than he could. I did revisit the ground, and also met the committee, when I again indicated that there was nothing in the objections which could not be met. The only serious objection was that referring to the difficulty which might be experienced in acquiring the site for the Installation No. 1. It is quite possible that difficulty and opposition might be encountered in this matter of acquiring a site—in schemes of this sort that is the general experience—but that difficulty is not insuperable; and I am ready to admit that it might be possible, with the aid of the local knowledge of the defenders, to find a site in the same direction which would be more easy of acquirement than the one indicated, and which would still harmonise with the general scope of my scheme. I think the committee were impressed with my views, and, as we discussed the whole matter from a practical point of view, came to regard my scheme with a more favourable eye.

"I do not think any of the objections constitute *reasonable* arguments for upsetting or throwing out the scheme, although one or two of them are worthy of consideration, in the view of avoiding difficulties which might crop up. These refer to the question of the selection of sites for the purification works.

"In my opinion the only effect which should be given to these objections should be to allow a certain amount of latitude to the defenders to meet difficulties, such as always occur in connection with such works, by modification of details, and, in any case, to leave them a comparatively free hand in the selection of sites for the purification works, so long as the selection made did not interfere with the general efficiency of the whole scheme. At the present stage of the business, it would be a mistake to tie the Defenders in a hard and fast way to any particular sites, as that would place them in a most disadvantageous position for acquiring on the best terms.

"Reported by

"Wm. Allan Carter."

Feb. 17.—Case before Mr. Sheriff Thomson, when motion made by Pursuers for Order. *Burgh of Motherwell.*

Feb. 20.—Order by Sheriff Thomson. Having heard parties' procurators and considered the additional report by Mr. Carter, No. 34 of Process, ordains Defenders as soon as reasonably practicable to execute the work to be done in accordance with Mr. Carter's reports, Nos. 31 and 33 of Process, at the sight and to the satisfaction of Mr. Carter, reserving power to either party to apply to the Court at any time for direction, and continues the cause *sine die*.

(Sgd.) A. S. D. Thomson.

Mar. 3.—Decree for expenses to date granted in favour of Pursuers.

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(2) THE WESTBURN COLLIERY COMPANY.

1901.

Nov. 25.—Consent to action by Secretary for Scotland.

1902.

May 22.—Petition presented.

June 3.—Case continued till 6th for defences.

„ 6.—Defences lodged and case continued till 13th.

„ 13.—Case continued till 20th on Pursuers' motion.

„ 20.—Case continued till 24th on Pursuers' motion.

„ 24.—Case continued *sine die* in order that Pursuers might raise a supplementary action.

July 8.—Case called and continued till 15th July on Pursuers' motion.

„ 15.—Case called and continued till 22nd July on joint-motion.

„ 22.—Case called and continued till 25th July on Defenders' motion.

„ 25.—Case called and continued till 29th July on Pursuers' motion.

„ 29.—James Hamilton sisted as an additional Defender.

„ 30.—Interlocutor by Sheriff Davidson:—Robert Hamilton assoilzied, and case continued till 7th October.

Oct. 7.—Record closed, and debate fixed for 9th instant.

„ 9.—Debate, avizandum made.

„ 17.—Interlocutor by Sheriff Davidson:—"Hamilton, 17th October, 1902. Having heard parties' procurators and made avizandum, allows a proof before answer, and sends the case to the Roll of 24th October current to fix a diet.

"(Sgd.) Mark George Davidson.

"Note.—The pursuers are, I have no doubt, bound by the terms of the letter of consent from the Secretary for Scotland. Whether they are still in right of that consent or not is matter for proof.—(Intd.) M.G.D."

1902.

Oct. 23.—Defenders appeal to Sheriff-Principal. Case sent to Appeal Roll of 3rd December.

Dec. 3.—Debate before Sheriff-Principal, avizandum made.

„ 19.—Interlocutor by Sheriff-Principal:—"Having heard parties' procurators under reference to the subjoined Note, adheres to the Interlocutor appealed against, and remits to the Sheriff-Substitute for further procedure.

"(Sgd.) Robert Berry.

"Note.—The consent of the Secretary for Scotland to proceedings of the County Council being taken against the defenders, as conveyed by the Under-Secretary's letter of 25th November, 1901, must, I think, be taken

Westburn Colliery.

as superseding the terms of the previous consent given in May, 1899. The consent of 25th November is given, subject only to the understanding that 'the proceedings will be taken in due course.' Immediately on receipt of this letter of consent on 26th November, the county clerk intimated, in writing, to the defenders that in terms of Section 13 of the Rivers Pollution Prevention Act, it was the intention of the County Council to take proceedings against the defenders in respect of an offence or offences committed under the Act, through causing a pollution of the Gateside Stream by coal-dross washing operations at their Westburn Colliery.

"It is provided by the Act that proceedings shall not in any case be taken for an offence against the Act until the expiration of two months after written notice of the intention to take such proceedings has been given to the offender. This interval of two months is no doubt allowed to persons in the position of the defenders, in order that they may, if so advised, take steps to stop the pollution in respect of which proceedings are contemplated. At its expiration it is proper and indeed the duty of the sanitary authority to make enquiry, and to be in a position, if necessary, to prove that efficient steps have in the interval not been taken to stop the pollution complained of, and until they have had the opportunity of making such enquiry it would be premature for them to institute proceedings. In the present case the two months' interval did not expire till about the end of January, 1902; and I gather from the averments in Article 5 of the Condescendence that during the months of February, March, and April, the pursuers were engaged in making investigation as to whether the pollution had been abated or was still continued. The last date of alleged pollution is on 24th April, and on 22nd May warrant of service on the petition was granted. Taking it to be the case that the pursuers were engaged in such investigation on occasions during the months prior to service of the petition, I think it would follow that the understanding or condition on which the consent of the Secretary for Scotland was given, that the proceedings should be taken in due course, has been fairly observed. It is no doubt matter for proof whether they were so engaged, and found the pollution to be continued as they aver; and should evidence be tendered to the effect that the terms of the consent had not been complied with, it would properly be admitted. I would just observe, however, that rules of time which have been established by long usage in mercantile matters, such as were suggested to me at the bar, have no real bearing on the case.

"What I have said suffices, I think, to meet another objection which was taken by the defenders at the debate, viz.:—that the alleged acts of pollution in February, March, and April, 1902, cannot be considered, being, it was said, too late, subsequent as they were to the date of the Secretary for Scotland's letter of 25th November, 1901, giving consent to proceedings being taken for an offence under the Act. The offence of pollution is of a continuous nature, and evidence of its continuance on dates subsequent to the interval allowed by statute before proceedings can be instituted is properly admissible to show that no efficient steps to abate the pollution had been taken.

"The proof allowed, it will be understood, is a general proof on the whole case. It is not limited to the question whether the terms of the Secretary for Scotland's letter of consent have been complied with, as in one view of the Sheriff-Substitute's note it was suggested might be maintained.—(Intd.) R.B."

1902.

Dec. 23.—Proof fixed for 4th February, 1903.

1903.

Jan. 20.—"Refuses the motion, No. 14 of Process, and grants leave to Appeal. (Sgd.) MARK GEORGE DAVIDSON." *Westburn Colliery.*

,, 24.—The Defenders appeal to the Sheriff.

Mar. 6.—Case sent to Appeal Roll of 11th March.

Mar. 11.—Debate before Mr. Sheriff-Principal Guthrie.

Mar. 17.—Interlocutor by Sheriff-Principal:—"Having heard parties' procurators, adheres to the Interlocutor appealed against, and remits to the Sheriff-Substitute for further procedure.

"(Sgd.) W. GUTHRIE.

"NOTE.—I agree that the call as it stands is far too wide. It was materially restricted by the Defenders' procurator at the debate, but I am still unable to differ from the interlocutor under review. What is asked is truly an exposure of the whole case for the prosecution. I hardly understand why leave to appeal was granted.—(Intd.) W.G."

1903.

Mar. 18.—Case enrolled before Sheriff Thomson for further procedure.

Mar. 20.—Diet of proof fixed for 27th April.

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(3) TURNERS, LIMITED.

1901.

Mar. 11.—Consent by Secretary for Scotland to action.

1902.

June 9.—Petition presented.

,, 20.—Case called, defences lodged, and case continued till 1st July.

July 1.—Record closed, and proof fixed for 24th July—the Defenders' motion to remit to referee on question of whether or not pollution was occurring being refused.

,, 9.—Appeal by Defenders to Sheriff-Principal—proof discharged.

Sept. 3.—Debate before Sheriff Berry, when Sheriff refused to remit, and Defenders then agreed to lodge minute admitting pollution, in order that remit might be made, and case continued for this purpose. Case put on Roll of 8th October.

Oct. 8.—Case before Sheriff-Principal, when, in respect of minute for Defenders admitting pollution, Sheriff stated he would remit to Mr. Alexander Frew.

,, 22.—Case on Roll on Defenders' motion, when Mr. Frew's appointment objected to by Defenders—discussion and remit allowed to stand.

,, 30.—Interlocutor by Sheriff Berry:—"Having heard parties' procurators, recalls the Interlocutor appealed against, finds, in respect of the minute of admission for the Defenders (No. 7 of process), that the Defenders had before and at the date of the raising of the present action failed to take sufficient means for preventing the flow of noxious and polluting liquid proceeding from their collieries situtated near to the Blind Burn, into the said Blind Burn, a stream, within the meaning of the Rivers Pollution Prevention Act, 1876. Finds it averred in the said minute that, since the date when this action was raised, the Defenders have completed certain operations which have had the effect of doing away with said pollution. Before further answer remits to Mr. Alexander Frew, Civil Engineer, 140 West George Street, Glasgow, to report whether the operations referred to in the said minute,

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as now taken by the Defenders, have had the effect of doing away with the pollution of the stream from their works, and, if not, to report further as to the best practicable and available means of preventing such pollution, and the nature and cost of the works and apparatus required, he having, if necessary, power to consult such chemical or other authorities as may be found necessary or expedient for the purposes of the remit. (Sgd.) ROBERT BERRY."

Nov. 13.—Inspection of works by Mr. Frew.

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(4) JAMES DUNLOP & CO. (1900), LIMITED.

1901.

May 31.—Consent to action by the Secretary for Scotland.

Dec. 17.—Petition presented. Case continued for defences.

1902.

Jan. 7.—Defences lodged, and case continued till 17th for parties to adjust.

„ 17.—Debate fixed for 23rd.

„ 23.—Debate before Sheriff Mair, when avizandum made.

Mar. 31.—Interlocutor by Sheriff Mair dismissing action:—"Having heard parties' procurators, and considered the cause, sustains the first, second, and third pleas-in-law for the Defenders, and dismisses the petition: finds the Defenders entitled to expenses, appoints an account thereof to be lodged, and remits the same to the Auditor of Court to tax and report, and decerns. (Sgd.) WM. LUDOVIC MAIR.

"NOTE.—This is a petition at the instance of the County Council of Lanark against James Dunlop & Co. (1900), Limited, to ordain the defenders to abstain from causing to fall or flow, or knowingly permitting to fall or flow, into the River Clyde, in the County of Lanark, any poisonous, noxious, or polluting liquid, &c., from their chemical works. The petition is brought under the Rivers Pollution Prevention Acts, 1876 and 1893. The Act requires (Section 13) that notice shall be sent to the party complained against some time before legal proceedings are taken. In the present case no notice was sent to the defenders. A notice was sent to James Dunlop & Co., Limited, on 6th June, 1901. That Company, however, went into liquidation, and went out of existence in August, 1900. The alleged offence was committed four months after James Dunlop & Co. went out of existence. It was stated at the debate, and not denied by the pursuers, that James Dunlop & Co., Limited, was a different *persona* from James Dunlop & Co. (1900), Limited. The notice was therefore served upon a defunct *persona*. James Dunlop & Co., Limited, was a private limited Company, confined, it was said, to the Donaldson family, whereas James Dunlop & Co. (1900), Limited, was composed of 5,000 or 6,000 people. It may be said this was a technical plea, but we are here dealing with a statute creating *quasi* criminal offences, and it must be strictly observed.—(Intd.) W.L.M."

1902.

April 2.—Appeal by Pursuers to Sheriff-Principal. Case sent to Appeal Roll of 14th May.

May 14.—Debate before Sheriff-Principal.

June 3.—Interlocutor by Sheriff-Principal reversing Sheriff-Substitute's Interlocutor:—"Having heard parties' procurators, recalls the Interlocutor appealed against, repels the first, second, and third pleas stated for the Defenders, and remits to the Sheriff-Substitute for further procedure. *Clyde Iron Works.*

"(Sgd.) ROBERT BERRY.

"NOTE.—The question here is whether this petition under the Rivers Pollution Prevention Acts, at the instance of the County Council, has been properly dismissed on the ground as put in the defenders' third plea that no formal notice of the pursuers' intention to take proceedings has been served on the defenders, as required by the Rivers Pollution Prevention Act, 1876. That Act provides (Sec. 13) that no proceedings shall be taken for any offence against the Act 'until the expiration of two months after written notice of the intention to take such proceedings has been given to the offender.'

"The defenders are James Dunlop & Company (1900), Limited, described as 'carrying on business at Clyde Iron Works, in the Parish of Old Monkland, and County of Lanark, and having their registered office there.' A notice of intention to take proceedings 'in respect of an offence committed by you * * * by discharging or allowing to be discharged into the River Clyde ammoniacal liquor from your works at Tollcross' was given by letter from the County Clerk of 6th June (1901), but the letter was addressed not to 'James Dunlop & Company (1900), Limited, Clyde Iron Works, Glasgow,' but to 'James Dunlop & Company (Limited), Clyde Iron Works, Glasgow.' The year 1900, which appears in the registered name of the defenders' Company, was omitted from the address, and it is in respect of that omission that the plea, which proceeds on no formal notice of the pursuers' intention having been served on the defenders, is rested.

"It appears that previous to the year 1901 a Company, under the name of James Dunlop & Company, Limited, had carried on business at the Clyde Iron Works, but that Company was wound up, and ceased to exist in the course of the year 1900, their business being transferred to a new Company, the present defenders, who were registered, and now carry on business at the same place, under the name of James Dunlop & Company (1900), Limited. There having been no Company in existence under the name of James Dunlop & Company, Limited, at the time of the County Clerk's letter of 6th June, 1901, it might well be maintained that the notice contained in that letter could be intended for no other than the defenders' Company, that they could not possibly be misled by the mistake in the address, and that the notice was sufficient under the Statute.

"I am, however, concerned to consider what might have been the position had matters rested there, and had an objection in respect of the misnomer been taken to the notice shortly after it was received. Instead, however, of any objection being suggested within reasonable time, we find that on 6th July, 1901, defenders' law agents, Messrs. Moir & Forbes, wrote to the County Clerk a letter, in which they say—'Our clients Messrs. James Dunlop & Company (1900), Limited, sent us a copy of your letter to them of 6th June, and we have been going into the matter with them.' The agents go on to represent that the operations of their clients are not so conducted as to pollute the river, they suggest a meeting with the view of coming to an arrangement satisfactory to both parties, and

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they conclude—'If the meeting should not result in any suggestions being adopted, the proceedings intimated can go on; but we should think that it ought to be possible to render these unnecessary.'

"Negotiations followed, but these proved fruitless, and ultimately, in December, 1901, the present proceedings were taken by the County Council.

"I think it impossible to give effect to the objection now taken by the defenders to these proceedings in respect of the misnomer in the county clerk's notice of 6th June, 1901. The defenders were not in any way misled by the omission from their name of the year 1900; they themselves treated the notice as applicable to them; and said by their law agents that the proceedings could go on if the proposed endeavour to arrange matters should prove unsuccessful. The object of the notice required by the Act is obviously to prevent persons said to be polluting a stream from being taken by surprise and proceeded against under the Act without reasonable warning. A warning, subject to the verbal criticism now put forward by defenders, was given to them; they accepted that warning as sufficient; and after negotiations, extending over months, they now seek to rely on the critical objection to the name under which they were addressed as sufficient to render nugatory the proceedings which they formerly intimated might go on. The objection ought not, in my opinion, to be allowed any effect.

"The case of the defenders was sought to be buttressed in the argument before me by a reference to the letter from the Secretary for Scotland giving, as is necessary, his approval to the institution of these proceedings, in which he makes a similar omission in naming the Company to that made in the pursuers' notice. His letter of approval is dated 31st May, 1901, after the Company, James Dunlop & Company, Limited, had gone out of existence, and it is idle to contend that proceedings against any other than the defenders' Company were intended by him.

"In the concluding sentence of the Sheriff-Substitute's Note, as a ground for giving effect to what he justly describes as a 'technical plea,' it is said 'we are here dealing with a statute creating *quasi* criminal offence, and it must be strictly observed.' On this point I would refer to the language of the Lord Justice Clerk Moncrieff in the Portobello case, 1 OR, at page 138, where he says 'it is a hybrid statute, which involves penalties only in the event of disobedience to the directions of the Court, but the first and primary jurisdication is one in a purely civil action.' To enable that civil jurisdiction to be put in motion, the Act requires notice to be given to supposed offenders. Notice, which the defenders themselves accepted as sufficient, was given in the present case, and nothing more was necessary. (Initd.) R. B."

Proof fixed for 17th July.

1902.

July 17.—Proof before Sheriff-Substitute Mackenzie, and continued proof fixed for 11th October.

Oct. 11.—Proof before Sheriff-Substitute, when same partly heard, and adjourned till 13th.

" 13.—Proof concluded, and case continued for debate till 3rd November.

Nov. 3.—Debate before Sheriff-Substitute—avizandum made.

" 29.—Interlocutor by Sheriff Mackenzie:—"Having heard counsel for the parties on the proof and productions, and considered the cause, finds in fact (1) that the defenders

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are the proprietors of works known as Clyde Ironworks, situated near the River Clyde, at a point within the Parish of Old Monkland and County of Lanark; (2) that part of said works consists of a chemical factory for the recovery of ammonia; (3) that, from about the middle of December, 1900, down to about the middle of September, 1902, the defenders caused to fall or flow from their said factory into a stream running through their works into the Clyde, and so to fall or flow into the Clyde, about 25,000 gallons a day of spent ammoniacal liquor; (4) that this spent liquor is a poisonous, noxious, or polluting liquid, and that the water of the said stream was so contaminated with said spent liquor as to be a poisonous, noxious, or polluting liquid at the point where it flowed into the Clyde: and (5) that the Clyde at said point is not a tidal water: finds in law that the defenders, in causing the spent liquor from their factory to flow into the Clyde, contravened Section 4 of the Rivers Pollution Prevention Act, 1876; therefore ordains the Defenders to abstain from causing to fall or flow, or knowingly permitting to fall or flow, or to be carried into the River Clyde, in the County of Lanark, any poisonous, noxious, or polluting liquid, and, in particular, the poisonous, noxious, or polluting liquid refuse from their chemical works at Clyde Ironworks, in the Parish of Old Monkland and county aforesaid; and decerns: finds the defenders liable to the pursuers in expenses on the higher scale; certifies John Thomson Wilson, John Clark, John Glaister, Andrew J. Laird, Walter K. Cheshire, James Weddell, Alexander Frew, Gordon Thomson Frew, and Alexander M'Lelland, referred to in the Motion No. 12 of Process, as skilled witnesses, for additional allowance in terms of the Act of Sederunt of 4th December, 1878, and sanctions and approves of the employment of counsel in the conduct of the cause; appoints an account of said expenses to be lodged, and remits the same when lodged to the Auditor of Court to tax and report. (Sgd.) A. O. M. MACKENZIE."

"NOTE.—This is an application by the County Council of Lanarkshire, under the Rivers Pollution Prevention Act of 1876, to have James Dunlop & Company (1900), Limited, who carry on business at the Clyde Ironworks, ordained to abstain from causing to fall, or knowingly permitting to fall into the River Clyde, 'any poisonous, noxious, or polluting liquid' from their chemical works.

"By Section 4 of that Act it is enacted that 'every person who causes to fall or flow, or knowingly permits to fall or flow or to be carried into any *stream* any poisonous, noxious, or polluting liquid proceeding from any factory or manufacturing process shall'—subject to an exception to which it is unnecessary further to allude—'be deemed to have committed an offence against this Act.'

"By Section 10 the County Court having jurisdiction in the place where any offence against the Act is committed is empowered, by summary order, to require the offender to abstain from the commission of such offence, and penalties are imposed on any person failing to comply with any requirement of an Order of the Court.

"By Section 20, 'stream' is defined as including tidal waters to such point as may be determined by the Local Government Board, by order

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published in the *Edinburgh Gazette*, but, with this exception, as excluding tidal waters. No order relating to the part of the Clyde at which the defenders' works are situated has been pronounced by the Board.

"The complaint is that the defenders have for some time caused to fall into the Clyde from their chemical works a poisonous, noxious, and polluting liquid, known as spent ammoniacal liquor, and a number of dates are given on which this is said to have occurred.

"The defenders deny, in the first place, that they have discharged poisonous liquid into the Clyde; and, in the second place, that the Clyde at the point in question is a stream within the meaning of the Act.

"Since the action was raised—indeed, only a few weeks ago—the defenders have set evaporating plant in operation for the purpose of evaporating the spent liquor from their ammonia works. It is admitted that this is not only the best known, but is a perfectly efficacious method of preventing pollution from the spent liquor; but the pursuers maintain that, in respect of the actings of the defenders—to which I shall afterwards allude—they are, nevertheless, entitled to the order craved in the application.

"Three questions, accordingly, have to be determined :—

"1. Whether the defenders did in fact cause a poisonous, noxious, or polluting liquid flow into the river?

"2. Whether the river opposite their works is a stream within the meaning of the Act or a tidal water? and

"3. Whether, seeing that the ground of complaint no longer exists, the pursuers are entitled to the Order they crave?

"I shall deal with these questions in their order.

"1.—As regards the facts bearing on this question, there is no serious dispute. The defenders, as part of their business, manufacture ammonia from the smoke and gas from their blast furnaces. It is unnecessary to describe the process. It is enough to say that in course of it an ammoniacal liquor is formed, and after as much of the ammonia as possible has been extracted from it, the liquor, which has then become what is known as spent liquor, is allowed to flow off. The quantity of this liquor discharged from the defenders' stills per diem is estimated by the defenders' witnesses, Drs. King and Tatlock, at 50,000 gallons. It is not disputed that as it comes from the stills this liquor contains a considerable quantity of highly poisonous substances known as phenols. A sample taken by Dr. Tatlock on 28th December, 1901, and analysed by him was found to contain 133 grains of phenols to every gallon of water. It appears that complaints of pollution by the discharge of this liquor into the Clyde were made as far back as 1896, and in order to remove the ground of complaint the defenders' predecessors, James Dunlop & Company, instituted an evaporating plant which was found to have the desired result. The use of this plant was, however, after a certain time discontinued, and another method of treating the spent liquor adopted, namely, by pouring it over the hot slag which was brought from the blast furnaces and tipped in a molten state. This method of dealing with the spent liquor seems, from the evidence of the witness Gray, to have been adopted in the spring of 1899. No notice of the change in the method of treating the spent liquor was given to the County Council; but, in the summer of 1900, their inspectors reported that polluting liquid was being discharged from the works, and complaints were made to the defenders. As these complaints did not meet with a response satisfactory to the county authorities, systematic inspections were made, and a number of samples were taken from the outflow of a small water course which makes its way to the Clyde

past the side of the slag hill. Those samples were analysed by the pursuers' witnesses, Dr. Clark, Public Analyst for the County, Professor Glaister, of Glasgow University, Dr. Laird, Medical Officer for the Burgh of Crewe, and Mr. Cheshire, chemist in the public health laboratory at Hamilton. The samples were taken at various periods between 13th December, 1900, and 15th July, 1902, and the earlier ones were subjected to the oxygen test; the later to a minute analysis. The result of the analyses was to prove to demonstration that the spent liquor was not being entirely evaporated on the slag hill, but that a very considerable quantity of it was finding its way into the small stream to which I have referred, and thence into the Clyde. The oxygen tests proved that the water of this effluent was highly charged with organic impurity, and the later analyses that the noxious ingredients consisted largely of phenols, which were found present in amounts varying from above 32 to about 6 grains per gallon, the variation no doubt being due to the varying heat of the slag upon which the spent liquor was poured as it came from the stills. The experiments made by Drs. Clark and Glaister proved that even when much diluted with pure water the liquid from the effluent was destructive to fish life. The accuracy of the results at which the pursuers' skilled witnesses arrived is not seriously traversed by the defenders. Indeed, they do not seriously dispute that the water of the effluent as it flowed into the Clyde was so contaminated with spent liquor as to be in itself a poisonous and noxious liquid. Their case is that, in order to establish a contravention of Section 4, it must be proved that the noxious liquid discharged into the river has a polluting effect upon the water of the river, and they maintain that the amount of noxious liquid discharged from their works is so small as compared with the volume of the Clyde, that it can and does have no polluting effect whatever on the river. Now, while I cannot accept this latter statement as absolutely correct, seeing that the presence of the noxious liquid can be detected by the eye, and its poisonous nature discovered by analysis of samples taken twenty yards below the point of outfall, it is the case that if and when thoroughly mixed with the water of the river the spent liquor is so diluted that it can have no polluting effect on that water discoverable by analysis. This, however, does not to my mind afford an answer to the complaint, as I cannot accept defenders' construction of the Act. In my opinion, the words of Section 4 are plain, and their meaning is that an offence against the Act is committed by any manufacturer who causes any appreciable quantity of poisonous, noxious, or polluting liquid to flow into a stream from their works. The word 'polluting' is, it may be observed, used not as additional but as alternative to 'poisonous' and 'noxious,' and construing the clause to the best of my ability, I reject the defenders' contention. A consideration of the other provisions of the Act confirms my view. In the first place, the declared purpose of the Act is to make 'further' provision for the prevention of the pollution of rivers, and in particular 'to prevent the establishment of new sources of pollution.' It appears to me that the enacting clauses would come short of the declared purpose of the Act if they merely empowered local authorities to complain of sources of pollution illegal at common law. Again, a reference to Section 2 shows that the legislature were quite aware of the distinction between a substance noxious in itself and one having a polluting effect on the river, and that when they intended to make it an offence to discharge refuse into a river, only if such refuse had a polluting effect on the river, they knew how to make their meaning clear. Further, a comparison of Section 3 certainly suggests that there is no reason to hold that the plain words of Section 4 require to be construed in other than

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their literal meaning, for it is clear that Section 3 gives the local authority power to object to any sewage matter whatever, however insignificant the quantity, being discharged into a stream, and, that being so, one does not see why it should be thought that the legislature could not have intended to confer on the same authority a similar power in regard to the discharge of noxious liquid from a factory. Lastly, the care with which the exercise of the powers conferred by Section 4 are guarded so as to prevent the possibility of these powers being used harshly and to the detriment of industry, suggests strongly to my mind that they were recognised to be of a novel and extensive character. These considerations lead me to the conclusion that an offence against Section 4 is committed whenever any appreciable quantity of poisonous, noxious, or polluting liquid is caused or permitted to flow from a work into a stream to which the Act applies. Now, the amount of spent liquor from defenders' works which, on the estimate of their own witnesses, finds its way into the river is 25,000 gallons a day, which certainly cannot be called a negligible quantity, and it is proved that the water of the stream by which it is carried into the Clyde is so contaminated as to be poisonous and noxious when it flows into the Clyde. I am, therefore, of opinion that it is proved that the defenders have, from the end of 1900 to a period long after the raising of this action, been causing 'poisonous, noxious, or polluting liquid,' in the sense of the Act, to flow into the Clyde.

"2.—The next question is, whether this part of the Clyde is a 'tidal water' within the meaning of the Act. The expression as used in the Act has never been construed, but I see no reason to think that the words have any other than their ordinary legal meaning. Unfortunately, however, no rule has ever been laid down for determining the upward limit of the tide in a river channel. The defenders' contention is, that a river is tidal up to the extreme point at which the influence of the tide can be traced by a heightening of the water level at high tide of ordinary spring tides. I agree that, in considering the question of tide limit, whether on the shore of the sea or in a river channel, the limit of ordinary spring tides is the criterion (Nicol *v.* Blaikie, 22 D. 335; Officers of State *v.* Smith, 8 D. 711, per Lord Moncrieff at p. 721; Agnew *v.* Lord Advocate, 11 Macph. 309, per Lord Ormidale at p. 312, and Lord Neaves at p. 331; Dowie *v.* Marquis of Ailsa, 14 R. 649, per Lord Trayner at p. 661), but I cannot agree with the further proposition that tidal waters extend in a river so far as tidal influence can be traced. The ordinary legal language descriptive of a tidal river is one in which the tide 'ebbs and flows' (Colquhoun's Trustees *v.* Orr Ewing & Co. 4 R. 542, per Lord Pres. Inglis at p. 354, and Murphy *v.* Ryan, 2 Irish Common Law Rep. 143), and these words, to my mind, suggest a river in which there is a perceptible upward flow of the incoming tide. Moreover, the contention of the defenders was considered and rejected by a unanimous judgment of the Second Division in the case of Dowie *v.* Marquis of Ailsa, 14 R. 649. In that case the pursuer, as a member of the public, claimed right to fish for white fish on the River Doon as far as the highest point reached by ordinary spring tides, and the question was thus raised—how far the tidal waters extended? In dealing with this question, Lord Justice-Clerk Moncrieff said: 'Of course, the hydrostatic effect of raising the level of the salt water through the action of the tide is to raise also the level of the fresh water, which is obstructed by the higher level to which the salt water has ascended; but I think that the result of the evidence is that no salt water, or at least no material saline quality in the water, is to be found at Doonfoot dam dyke, or considerably below it. Now, upon this matter a great deal of legal lore

has been expended in other cases, but I do not think that the question has ever arisen as to whether the fact that fresh water has had its level raised through the influence of the tide constitutes it to the extent to which that rising has taken place a part of the sea. I think it does not.' The river there in question was the River Doon, but there is nothing in the evidence to suggest that the Clyde opposite the defenders' works differs in character from that river. At the point in question the Clyde has all the characteristics of an ordinary fresh-water stream. It is confined by banks, and the river water contends from bank to bank. There are no sands or flats left dry at low tide, and there is no evidence to show that salt water ever reaches to the defenders' works, or that an upward movement or flow of the water is ever perceptible there. Such being the character of the river at the point where the spent liquor is discharged into it, I have no hesitation in holding that it is not at that point a tidal water in the sense of the Act. This makes it unnecessary for me to consider the effect of the evidence adduced by the defenders to show that the influence of the tides can be traced opposite the defenders' works, but I may say that, even if I had been able to accept their proposition in law, I would have had great difficulty in holding that they had succeeded in proving that, at the point in question, the river was to any extent subject to tidal influence at ordinary spring tides.

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"3. The only remaining question is, whether the fact that the defenders have lately disposed of the spent liquor by a method of evaporation disentitles the pursuers to the order they crave, and the conclusion at which I have arrived is that it does not. My reasons may be shortly stated. Complaints of the discharge of spent liquor were made in 1896, and a correspondence on the subject took place between the Secretary for Scotland and the defenders' predecessors, James Dunlop & Company, Limited. Thereafter, the works were visited by a Government inspector, and finally the complaints were obviated by James Dunlop & Company instituting an evaporating plant which was found to be an efficient method of disposing of the spent liquor. Two years later, however, the Company, for reasons of economy and convenience to itself, discontinued the use of the evaporating plant, and adopted the method of treating the spent liquor by pouring it over their hot slag, which, it has been clearly proved, was not an effectual method of evaporation. Before adopting this method, the Company gave no notice of their intention to the Local Authority, and apparently took no trouble to test its efficiency. This faulty method of treatment was continued after the works were transferred to the defenders, and the result has been that about half the spent liquor has been finding its way into the Clyde. Now, the object of the incorporation of the new Company was the amalgamation of the business of the old Company with that of the Calderbank Steel Company, and, so far as the present question is concerned, I think the defenders must be held to stand in the shoes of James Dunlop & Company, Limited, and to be affected by any criticisms to which the actings of their predecessors are exposed. Moreover, the defenders, so far from showing themselves ready to satisfy what I have held to be the just complaints of the pursuers, have strenuously maintained that they were not contravening the Act. Neither their past conduct, accordingly, nor their present attitude give any great assurance that they would not again give cause of complaint by discharging spent liquor into the river, if they should find it convenient to do so, and could do it without attracting the attention of the pursuers' inspectors. In these circumstances, I am of opinion that the pursuers are entitled to the order they ask, which will enable them, in the

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event of the defenders abandoning the use of the evaporating plant, to exercise the further means of compulsion provided by the Act.

"(Intd.) A. O. M. M."

1902.

Dec. 3.—Defenders appeal to Sheriff-Principal.

1903.

Feb. 11.—Appeal withdrawn.

„ 27.—Auditor's report on Pursuers' account of expenses approved.

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(5) THE CARNBROE CHEMICAL COMPANY.

1899.

May 12.—Secretary for Scotland's consent to action.

July 7.—Petition presented.

„ 18.—Defences lodged.

„ 28.—Case continued on Adjustment Roll till 26th September.

Sept. 26.—Case continued on Adjustment Roll till 29th September.

„ 29.—Debate before Sheriff Mair on Defenders' preliminary pleas. Record closed, and avizandum made.

1900.

Mar. 10.—Interlocutor by Sheriff Mair repelling Defenders' preliminary pleas, and allowing proof.

„ 16.—May 17th fixed for proof.

May 17.—Diet superseded, and 4th June fixed in lieu thereof.

June 4.—Proof partly led before Sheriff-Substitute, and adjourned till 9th June.

„ 7.—Diet superseded, and 21st June fixed in lieu thereof.

„ 15.—Diet superseded, and 29th June fixed in lieu thereof.

„ 22.—Diet superseded, and 12th July fixed in lieu thereof.

July 12.—Continued proof led, and adjourned till 26th July.

„ 24.—Diet superseded. Case sent to Roll of 18th September to fix a new diet.

Sept. 18.—October 25th fixed for continued proof.

Oct. 25.—Continued proof and debate—avizandum made.

Nov. 13.—Sheriff-Substitute—Interlocutor finding that Pursuers had failed to prove Defenders guilty of offence charged:—"Having heard parties' procurators, and considered the cause, finds that the Pursuers have failed to prove that the Defenders have been guilty of an offence, under Section 4 of the Rivers Pollution Prevention Act, 1876, therefore refuses the prayer of the petition, and assoilzies the Defenders from the conclusions of the action, and decerns; finds the Pursuers liable to the Defenders in expenses as on the higher scale; allows an account thereof to be lodged, and remits the same to the auditor of court to tax and report; certifies Mr. R. R. Tatlock, Analyst, Glasgow, for special fees.

"(Sgd.) Wm. Ludovic Mair.

"Note.—This is an application under the Rivers Pollution Prevention Act, 1876, and seeks to prevent the defenders from polluting the North Calder River, a stream admittedly a very dirty one, and containing quantities of both sewage and poisonous matter of various kinds. These other pollutions come from sewers and other works—some of which are similar to defenders'—chiefly situated above defenders' works; and I think it is clear that at common law no riparian proprietor could object to the defenders doing even what the pursuers allege they do.

"I have to deal, however, with an offence under an Act of Parliament which seems to strike at the pollution of certain streams, irrespective of their normal condition and of the fact that other people contribute largely to the pollution; and the only question to be decided by me is whether the defenders have contravened Section 4 of the Act. *Carnbroe Chemical Works.*

"The defenders' works are chemical works, and they extract from the bye-products or gases from the adjacent iron-works ammonia, oil, and tar. One of the parts of their process is the *washing* of the gases; and this process produces a considerable quantity of apparently poisonous liquid, known as 'spent liquor.' It is established from the evidence that, many years ago, before the defenders had all the modern improvements in their works which they now have, a considerable quantity of this spent liquor found its way into the Calder. It is conclusively proved, however, that for the past few years the defenders have used in their steam boilers all the spent liquor made by them, and the pursuers do not suggest any other source of pollution from their works, unless it be surface drainage, to which I shall subsequently refer.

"The pursuers, however, do not attack the methods upon which the defenders worked some years ago, but attempt to prove that, at the date of raising this action, they were polluting the river in the sense of Section 4 of the Act. They have led evidence on alleged pollution on two occasions —viz., on 7th April, 1900, when Dr. Wilson visited the works and took samples, and on 26th April, 1900, when Dr. Robb did the same. From the analyses taken from these samples, it would appear that polluted liquid entered the stream from defenders' works on these occasions, and the defenders' explanation is that on both occasions the occurrence was unusual and could not have been prevented, the former being due to a break-down at the works, and the latter to the mistake of one of their workmen.

"The pursuers maintain that, if they prove one single act of pollution, that is sufficient to constitute an offence under Section 4 of the Act; while the defenders, on the other hand, maintain that they have not contravened the Act unless it be shown that they are in the habit of systematically polluting the stream. An argument of considerable length was addressed to me on this part of the case by the defenders, to the effect that the pollution in question could not have been prevented through any foresight on their part, and that the Act was never intended to strike at an occasional or casual pollution which cannot be foreseen. Looking at the words of Section 4 of the Act, I am satisfied that their contention is sound. It provides that any one, to be guilty of an offence under this section, must knowingly permit poisonous liquid to proceed from the factory into the stream, and anticipates that such liquid is carried into the stream by a pipe or channel which has been constructed specially for that purpose. Now, had the defenders been in the habit of allowing the spent liquor to flow direct from the condensers and stills into the stream through a pipe, and although this had only occurred at remote intervals, I think they would have contravened Section 4 of the Act, as a certain amount of pollution would necessarily have ensued whenever the works were going in the usual way. Here, however, it is clearly established that the system by which the defenders' work is specially devised to prevent this spent liquor getting into the stream, and that it is only when some accident or break-down occurs, and their plant and machinery are thrown out of gear, that any pollution can take place. If we look to the terms of Section 3, we find that the language there is the same as Section 4. Section 3 deals exclusively with sewage; and surely it cannot be maintained that the Act

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was meant to strike at a discharge of sewage, say half-a-dozen times a year, which was not intentional, but was due to some unforeseen circumstance. That, of course, would be absurd, as a sewer usually forms part of a drainage scheme, and is specially constructed to carry all the drainage of a certain defined area. The sewage, of course, may vary in volume from time to time.

"I am therefore of opinion that, to constitute an offence under Section 4, the pollution must be more or less systematic.

"From the evidence, it is apparent that the pursuers are satisfied with the steps taken by the defenders to prevent pollution, and that their only cause of complaint is that occasional pollutions had occurred. Now the pursuers admitted that other works situated above the defenders' were guilty of polluting the stream from time to time, and that no prosecutions had been instituted. The defenders argued that this conduct on pursuers' part strengthened their theory that the Act did not apply to occasional pollutions, or the pursuers would have instituted proceedings against these other works long ago.

"The defenders suggested that the pursuers had started proceedings against them under the belief that they were discharging the spent liquor direct into the stream, and did not know that this could only happen in the case of some accident or some unforeseen circumstance. I think they were probably right in their suggestion, as we find Dr. Wilson, the principal witness for pursuers, stating that what he complains of is the defenders discharging the spent liquor into the stream, and admitting that he has never been inside their works, and is not familiar with the system upon which they work.

"Another suggestion made by pursuers is that a certain amount of surface drainage, which is necessarily dirty, finds its way into the stream. The Act was never intended to apply to surface drainage, and it has been proved that the defenders endeavoured to purify the surface drainage as much as possible—that is, they collect it from various parts of the works, and cause it to go through a separator, for the purpose of extracting any oil or ammonia which it may contain, and from the separator it runs into the stream by a pipe. If the defenders cannot be held at fault in allowing the natural surface drainage to fall into the stream, surely they cannot be in a worse position if they take steps to purify it, and then cause it to fall into the stream by means of a pipe.

"A point was raised by the defenders, viz.:—that the only evidence of alleged pollution by the pursuers was of pollution at a date subsequent to the raising of the present action. It is not necessary for me to decide the case on this point, but I am of opinion that the pursuers, in order to succeed in this case, would require to prove that the defenders were polluting the stream at or prior to the date when they instituted the proceedings under this Act, as I do not see why this should form an exception to the ordinary rule.

"As the alleged pollution is only occasional, it necessarily follows that there is a conflict in the expert evidence. Dr. Tatlock's analysis show the stream to be comparatively free from ammonia, oil, &c., while those by Dr. Clark are to the opposite effect.—(Intd.) W. L. M."

1900.

Nov. 21.—Pursuers' appeal to Sheriff-Principal.
Dec. 27.—Debate fixed for 6th February.

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1901.

Feb. 6.—Debate before Sheriff-Principal fixed for 13th February.

„ 13.—Parties heard by Sheriff-Principal.

„ 27.—Parties heard, when intimation was made by Sheriff-Principal that he was to recall Sheriff-Substitute's Interlocutor, and remit to a man of skill to report, and when he asked parties to suggest remittee to him.

April 10.—Case sent to Appeal Roll of 17th April.

„ 17.—Attendance before Sheriff-Principal, when he stated he was to appoint Mr. Syme as Referee.

May 1.—Case sent to Appeal Roll of 8th May.

„ 8.—Attendance before Sheriff-Principal, when Sheriff intimated that Mr. Syme would not act, and stated that he proposed to appoint Mr. David Rankine, C.E.

„ 20.—Attendance before Sheriff-Principal, at his request, when he intimated the appointment of Mr. Rankine.

„ 30.—Sheriff-Principal's Interlocutor :—"Having heard parties' procurators, recalls the Interlocutor of the Sheriff of 13th November last, appealed against: finds that the Defenders in the conduct of their chemical work, situated on or close to the bank of the North Calder River, a stream within the meaning of the Rivers Pollution Act, 1876, have failed to take sufficient means for preventing the flow of noxious and polluting liquid proceeding from their work into the said stream: finds that no such sufficient means having been taken, they have, on various occasions, caused or knowingly permitted quantities of spent ammoniacal liquor, the same being a noxious and polluting liquid within the meaning of the said Act, or some similar noxious or polluting liquid proceeding from their work, to flow or be carried into the said stream; finds, in particular, that they did so on the following dates, viz. :—3rd February, 22nd March, and 21st April, 1899; before further answer, remits to Mr. David Rankine, Civil and Mining Engineer, Glasgow, to report on the best practicable and available means for preventing the pollution of the stream in the manner aforesaid, and the nature and cost of the works and apparatus required, he having, if necessary, power to consult such chemical or other authorities as may be found necessary or expedient for the purposes of the remit; directs that in the meantime, and until further orders of court, the expenses of and incident to this remit, including the remuneration of the remittee, shall be borne equally by the parties to the cause, reserving to pronounce farther as to the manner in which these shall be borne by the parties, or either of them, ultimately.

"(Sgd.) ROBERT BERRY.

"NOTE.—A careful consideration of the proof in this case leads me to a different conclusion from that to which the Sheriff-Substitute has come. I think it proved that the defenders have, in the conduct of their works, acted in a way involving the commission of an offence within the meaning of the Rivers Pollution Prevention Act, 1876. The provision in Section 4 of the Act, under which the present proceedings are taken, enacts that—'Every person who causes to fall or flow, or knowingly permits to fall or flow, or to be carried into any stream, any poisonous, noxious, or polluting

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liquid proceeding from any factory or manufacturing process, shall be deemed to have committed an offence against this Act.' Now, it is not matter of dispute that, in the course of their business, which was established close to the banks of the Calder about the year 1890, the defenders have, if not continuously, at all events from time to time caused, or knowingly permitted to be discharged, poisonous or noxious liquid, into the river, and, in particular, what is known in the chemical industry as spent ammoniacal liquor—an admittedly noxious product. For a considerable time they were in the habit of pumping the spent liquor produced in their works on to a slag bing, but the result of that practice having been that the liquor found its way to the river, so as to cause pollution, they latterly adopted the system of using the spent liquor in their boilers. Mr. Walker, the manager, says it is about five years ago that they adopted that new system, but that the discharging of the liquor on to the slag heap had not ceased so soon appears from the evidence of more than one witness—Dr. Wilson, for example, speaking of having observed its effects when he made an inspection so lately as February, 1898. I understand, however, that the practice of discharging the liquor on to the slag bing has now ceased, and that it is not in respect to that practice that it is sought to establish the commission of an offence against the defenders. Still, I am of opinion that, although it may be not in that particular way, the defenders are shown in other ways to have knowingly permitted spent liquor or other polluting liquid to be carried into the Calder, if not continuously, at all events from time to time. I think, also, that that has been done, not by mere accident, but through the mode in which their works are knowingly conducted. The North Calder may well be called a dirty stream. It is quite unfit for primary purposes, and it is proved that pollutions are introduced into it at points higher up its course than the works of the defenders. These pollutions seems to be of different kinds from those for which the defenders are sought to be made responsible, and it is a question with which we are not concerned here, whether they are of a kind which could or could not be stopped by proceedings under the Statute. The non-institution of proceedings against them affords no ground of objection to the present action against the defenders. The evidence of Dr. Robb is material in considering whether the defenders are carrying on their works in breach of the Statute. He examined the river on 3rd February, 1899, and found a quantity of spent ammoniacal liquor issuing into the river from a pipe leading to it from below the defenders' office. It is suggested, as I understand, that that discharge is of the nature of surface drainage, for which the defenders should not be held responsible. The liquor, however, is said to come from the floor of their works, and if proper care were taken it should not be allowed to accumulate and find its way into the pipe which discharges into the river. Means might be taken for preventing it. As to the cause of pollution, Mr. Walker, the manager, says, 'We have a good lot of tarry water lying on the ground, a certain amount, and in wet weather, especially after a plump of rain, we are so situated on the stream that a certain amount of tar or oil' (these being characteristic components of spent ammoniacal liquor) 'is bound to go into the burn. The separator is quite effective except in an occasional downpour.' That, I am afraid, is not such an exceptional occurrence that it should be left without provision being made against it. Another cause of the spent liquor being carried into the river is the practice of the defenders in blowing off the boilers of their works for the purpose of cleaning them. The using of the spent liquor in the boilers causes the formation of a crust in them, and in blowing them off from time to time part of the residuary products is discharged.

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There are two tanks into which the contents of the boilers are blown off, and any deposit is expected to settle at the bottom. Occasionally, however, what is called the sludge pipe becomes blocked, and when that happens, the residuary products are, on the boilers being blown off, carried direct to the river. Such is the explanation given by Mr. Walker of an excessive amount of spent liquor which was found by Dr. Wilson to be issuing from the defenders' pipe into the river on 7th April, 1900. A similarly bad instance is spoken to by Dr. Robb when he visited the place on 26th April, 1900. Both these instances are subsequent in date to the institution of the present proceedings, and it may be that they are not admissible on these proceedings to establish an offence against the Statute on the part of the defenders. But if such a cause of pollution exists, as indeed is admitted by Mr. Walker, such instances may, I think, legitimately be referred to in illustration of the frequency with which the stream may be polluted in that way. Mr. Walker says, 'this block of the sludge pipe may occur twice in one week, and it might not occur twice in six or twelve months. It does not occur above six or eight times in the year.' Be it a more or less frequent occurrence, it is still an occurrence which it is in the power of the defenders to provide against. It might be provided against by letting the boilers cool down when they require to be cleaned, instead of blowing them off. That course is objected to by Mr. Walker on the ground of expense. If it is too expensive a remedy, he admits that the evil could be prevented by structural works. In one passage he says that their reception boiler (possibly that means reception tank) is not large enough, with the result that the overflow goes into the burn, that is, the stream of the Calder. That surely could easily be remedied. The evidence of Mr. Curphey, the Government Inspector under the Act, must also be noticed. Before the institution of these proceedings was consented to, as required by the Act, a report was made by him to the Secretary for Scotland. A copy of that report is in process, and, when examined as a witness, Mr. Curphey adopts what is said in it. He visited the stream on two occasions, viz., on 22nd March and 21st April, 1899, and on both occasions he found that the defenders were polluting the river by the discharge into it of a discoloured liquid, which he says may have contained spent ammoniacal liquor, although it was not in his opinion entirely of that character. The colour of the liquid was red, and it seems to have been suggested that that might have been caused by a discharge from certain print works higher up the river. He stated that he was prepared to say that the effluent was in itself red, apart from any print works. He found, as he tells us, that the defenders were using very largely their spent liquor for the steam boilers, and they asserted that they were using it all. He thought, however, that some of the liquor was getting away to some extent. He suggested certain improvements, and while there is evidence that some of these have been adopted by the defenders, it appears that they have not used all practical means to prevent pollution. He gives it as his opinion that it is possible for the defenders to prevent the pollution of the river, an opinion which is in accordance with the final paragraph of his report to the effect that 'although measures have been taken to considerably reduce pollution, more requires to be done,' and that 'such additional preventive means are reasonable and practicable under the circumstances.' My conclusion on the whole proof is that the defender's mode of conducting their operations involves an offence within the meaning of the Act. With regard to what has been called surface drainage, if they knowingly allow noxious or polluting liquor to escape in any considerable quantity to the floor of their works, so as to find its way to the river, close to the

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banks of which their works are situated, and that could be prevented by care or by disposing of the liquor otherwise, I think an offence has been committed. I am led to conclude on the evidence that that is the case here. Then we have the pollution caused every now and then when steam is blown off from the boilers. That is no doubt only an intermittent cause of pollution; but assuming that a certain degree of continuity in action, or in abstinence from action is necessary to constitute an offence under the Act, I am of opinion that a systematic avoidance, on the score of expense, to provide against a pollution which may be expected to occur with more or less frequency according to circumstances, and which it is possible reasonably to prevent, is sufficient to support an application for interdict. Such a course of action, or it may be of systematic abstinence from action, on the defenders' part has, I think, been established by the proof. I had hoped to have been able to issue this interlocutor sooner. A delay has occurred owing to my desire, before nominating a remittee to be assured of obtaining the services of a gentleman in whom I could have thorough confidence. I feel that I have been fortunate in being enabled to entrust the duty to Mr. David Rankine.—(Intd.) R. B."

1901.

June 18.—Defenders appeal to Second Division, Court of Session.
July 4.—Appeal dismissed, with £3 3s. expenses.
Sept. 20.—Inspection at Carnbroe.
Dec. 31.—Mr. Rankine's Report lodged.

1902.

Jan. 29.—Case before Sheriff-Principal, when objections by Defenders lodged and answers asked for.
Feb. 3.—Answers for Pursuers to Defenders' objections lodged.
" 5.—Case before Sheriff-Principal, when objections sent to Mr. Rankine to report.
" 15.—Inspection at Carnbroe.
" 20.—Mr. Rankine's Supplementary Report lodged.
Mar. 5.—Debate before Sheriff-Principal on Mr. Rankine's Supplementary Report, and Sheriff intimated that he would order Defenders to carry out work recommended by Mr. Rankine.
" 21.—Interlocutor by Sheriff Berry:—"Having heard parties' procurators, and considered the additional Report by Mr. Rankine (No. 16 of Process), ordains Defenders, as soon as reasonably practicable, to execute the work to be done in accordance with Mr. Rankine's Report (No. 12 of Process), as modified by his Report (No. 16 of Process), reserving power to either party, in the event of any difference arising in the course of the execution of the work, to call in Mr. Rankine, or apply to the Court for direction, and continues the cause *sine die*.

"(Sgd.) ROBERT BERRY."

II.—INDUSTRIAL POLLUTIONS.

Coal-Dross Washers.

Development of the Industry.—The washing of small coal for the purpose of getting rid of earthy matter has been practised in this country for nearly half a century, but it is only during the last fifteen years that it has become common in Lanarkshire. Such information as I have been able to obtain shows that only one or two washers were in operation prior to 1885, and that since then there has been a steady, rapid increase until 1897, when the number reached 61. At the close of the year 1902 there were 68 coal-washers in operation, although during these latter years a few of the older washers ceased operations. The amount of coal washed at each washery varies from 60 up to 300 tons a day for a single colliery, and up to 500 tons a day where the small coal from two or more collieries is dealt with. If we take 230 tons per washer as an average, then the amount of small coal washed daily in the Lanarkshire coal fields would be about 15,410 tons.

The great development in coal-washing has been due partly to the working of coal seams considered at one time to be unprofitable, because they contained such a large amount of earthy and other impurities, and partly to the demand of consumers for cleaner fuel. Evidence of these facts can be seen in the character and enormous size of the refuse heaps at many collieries.

Methods and Machinery.—The process of separating small coal from impurities by means of water is not a mere washing operation, as that term is usually understood, but an elutriation or separation according to specific gravity. Coal being lighter than clay and other earthy impurities, is readily separated from them by suitable appliances. The only washing done in the process is a final spraying of the coal after the separation has been effected. In all the methods a considerable quantity of water, as raised from the mine in a comparatively pure state, is seriously polluted in the washing operations, hence the interest such operations have from a rivers pollution prevention point of view. The amount of polluted water discharged from a washer is regulated chiefly by the method and machinery employed, but also by the amount of clay mixed with the coal. In October, 1888, the Council of the Mining Institute of Scotland appointed a committee to report upon the methods of cleaning coal, &c., throughout Great Britain. Their report was issued in 1890, and shows that the methods and

appliances in use for wet cleaning or washing varied according to circumstances.

The method originally employed was of a very simple nature, and may still be seen in operation at a few collieries in Lanarkshire. The object aimed at there is the separation of small pieces of coal from dirt; coal-dust or the smallest particles of coal are not recovered, but allowed to flow away with the clay or earthy material in the washings. Even in this simple method the plant varies, but to describe one may suffice. All the small coal passes over or through a screen, called a jigger, with apertures of three different sizes. The coal falls upon that part of the jigger which has the smallest apertures, and then passes on to the others, so that each succeeding screen in the series separates a larger size of coal, and that which passes over the last screen is the largest of all. As the coal falls on the first screen it receives a heavy spray of water, which washes out the smallest pieces of coal with the dirt, and carries them along in a trough to a screen which catches most of the coal, but allows the coal dust and dirt to flow away to a large settling pond. From this pond the water overflows to another pond, where it mixes with water as raised from the mine, and is again raised to the washer, to be used over again. The deposit in the pond consists not only of dirt, but coal dust, and the whole is removed in cleaning out the ponds to the refuse heap; thus a certain portion of coaly matter is not utilised.

At collieries where water from the mine is plentiful, the washings, after settling, are run off to the nearest stream, the water being used but once.

In order to understand the source and nature of pollutions generally met with, it will be desirable to describe in detail some of the more elaborate methods in use, such as the Luhrig coal washing plant and the plant made by Campbell, Binnie, & Co. The former is of German origin, and was first introduced into this county in 1890.

From a publication by the Luhrig Coal and Ore Dressing Appliances, Limited, the following quotation is made:—

"The process is automatic and continuous, and proceeds upon the gradual reduction system of sizing and washing. This process is the result of long and varied experience in some of the districts of Westphalia, Saxony, and Silesia, where the coals are of the dirtiest description. The system is, in short, a combination of new screening, crushing, and sizing machinery, improved washing machines, and new and greatly improved machinery for filtering the water used in the plant, so that it can be used over and over again.

"The coal, after being tipped over the screens, is taken over picking tables, where the large coal is sorted, and any foreign

matter removed, so that the coal is put into the market in the best possible condition. The fine coal, 2 inches downwards, is deposited in a hopper direct from the screens, or from waggons tipped by a hydraulic apparatus. From the hopper the fine coal is elevated to the sorting drum and sized, in most cases as follows :—

Size No. 5, Treble Nuts,	-	2 inches to 1½ inches.
„ „ 4, Double „	- -	1½ „ to 1 inch.
„ „ 3, Single „	- -	1 inch to ⅜ „
„ „ 2, Peas, -	- -	⅜ „ to ⅛ „
„ „ 1, Sludge, or gum,	-	under ⅛ „

"Each size of nut is then conveyed by a shoot into the washer and cleaned. The dirt is then elevated into a crusher, and any coal adhering is broken off, and the whole is rewashed. The fine coal is somewhat similarily treated in a washer specially adapted. There is also a sludge-recovery process, by means of which all the exceedingly fine coal is retained and prevented from flowing away with any water that may be run off, it will then be free from dirt. The rubbish or dirt which has been washed out is guaranteed not to contain more than 2 per cent. of fine pure coal. On account of the patent new filtering arrangement used in this process, very little water is required, for, as previously stated, the same water can be utilised repeatedly. 15 cubic feet per minute is sufficient to work an 800-ton plant."

From inspections made at different collieries where the Luhrig plant is in operation the following description may be given :— Speaking generally, the object aimed at is the separation of all, even the finest, coal from other material produced with it in mining operations. The separation is effected by (1) dry cleaning with mechanical appliances aided by the hand, and (2) wet cleaning, *i.e.*, by the use of water.

Following the process from beginning to end, the coal on being raised from the mine in hutches is tipped over a screen with 2-inch apertures. In this way the small material is separated and passes into a large storage bunker, while the lump coal passes on to a travelling table; female employees pick out the impurities—shale, clay, stones, and iron pyrites—leaving the clean coal, which is then tipped into waggons.

The building within which the coal washing is performed is four storeys high, and contains a sizing, a washing, and a silt-recovery plant. The small coal is raised from the storage bunker by means of an endless chain and bucket elevator to the top of the building, where it enters a cylindrical revolving screen 13 feet long, about 5 feet in diameter at the inlet end, and about 8 feet in diameter at the other end, with apertures 1½ inches diameter. Outside this is another screen somewhat shorter, and with 1-inch apertures. The third and outer screen is still shorter, and has apertures only ⅜ of an inch wide. The outlet end of each revolving

screen is connected with a separate shoot. As the coal is shot into the inner screen, four sizes of coal are thus separated—that retained in the innermost screen is known as treble nuts; that retained by the middle screen, double nuts; that retained by the outside screen, single nuts; and that passing through the third screen, peas or pearls.

The small coal thus separated into four different lots has now to be freed from dirt and other objectionable material. This is accomplished in two series of washers. These are wooden or iron, water-tight, hopper-shaped boxes, with metal sieves fitted near the top of the box. In the first series the nut coal is deposited on the sieves. An upward pulsating motion in the water is produced by means of a shaft, with eccentrics and plungers attached thereto, working in the water. The coal and other material resting upon the sieves of the washer is thus agitated, and as the coal is lighter than the other material it rises to the surface and is carried over the edge of the washer with the surface overflow of water, while the dirt falls to the bottom. Particles of coal, mixed with shale or brasses, having the specific gravity between the coal on the one hand and dirt on the other, occupy a middle position in the water, and thus by mechanical arrangements three separations can take place. The clean washed coal falls on to a jigger screen from which it flows into the storage hopper, but as it passes over the screen it receives a spray of clean water. The material collecting at the bottom and at the middle of the washer is removed at intervals by means of valves worked by levers, and is conducted to a well whence it is raised to the crusher by an elevator. From the crusher it is again taken to a washer, where complete separation and recovery of the coal takes place. The three sizes of nut coal are treated in precisely the same manner. From the storage hoppers railway waggons are loaded, and here we notice the first source of pollution by the drip from waggons of wet coal.

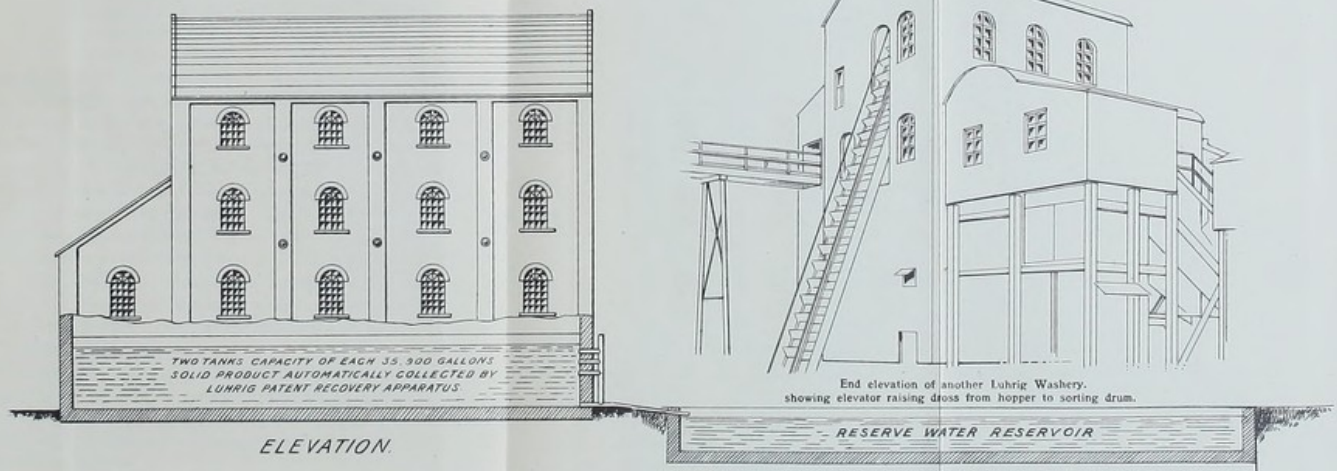
The fourth size is treated in a separate series of washers, to which the overflow water from the first series of washers is conducted. Here the washers are of special construction, in so far as it is necessary to provide some medium which will assist in separating the smallest coal from the other material, since, owing to the fineness of the mixture, the specific gravity does not vary greatly. This is accomplished by means of a layer of felspar put upon the sieves. The washed small coal from this series of washers is carried in the overflow water to a screen with very fine meshes. The material which does not pass through the screen is known as pearls, and is raised by elevators to storage bunkers. The dirty water passes through the screen still carrying small particles of coal, and constitutes one of the chief sources of pollution. The dirt washed out of the coal in the last series of washers falls to the bottom, and, being released from time to time, constitutes another source of serious pollution. These two discharges are purified by sedimentation. The coal gum or sludge in the one is recovered and used in the furnace boilers as fuel, while the dirt in the other is collected and elevated to the refuse heap.

COAL-DROSS-WASHERY

BUILDING ERECTED BY THE

LUHRIG COAL AND ORE DRESSING APPLIANCES, LTD

LONDON AND GLASGOW.



End elevation of another Luhrig Washery.
showing elevator raising dross from hopper to sorting drum.

ELEVATION.

PLAN.

Sedimentation is accomplished in a double-chambered tank, which occupies the whole of the ground floor of the building, there being a chamber for each of the two sources of dirty water above-mentioned. In the one chamber the suspended coal particles settle, and in the other the earthy material settles. The removal of the sediment from each chamber is effected, first, by a series of scrapers moving slowly on an endless chain towards a well from which it is elevated, the earthy material being conveyed to the waste heap, and the fine coal to the furnaces. This is usually the only fuel used at the colliery.

These mechanical arrangements are such as to prevent the escape of polluted liquid. It is the practice to run off the water from the tank at varying intervals, generally once a week, but at one washery recently erected ten months elapsed before the tank was emptied. The necessity for running off the tank water only arises when there is some breakdown, or when the machinery requires to be cleaned or examined. As the capacity of the tanks averages about 36,000 gallons, it is necessary to have settling ponds of sufficient area to hold this quantity. These ponds are generally formed near the refuse heap, and require to be cleaned out periodically. Sometimes provision is made for pumping the liquid from smaller collecting ponds to the top of the refuse heap, through which it filters or is dissipated.

The main points of interest in preventing pollution are (1) great reduction in the amount of polluted water discharged; (2) recovery of even the finest coal dust, and consequent reduction in the quantity of refuse; (3) continuous mechanical removal of the refuse to the top of the waste heap.

The following is a description of coal-washing plant by Campbell, Binnie, & Co., who have also supplied plans of the same:—

"The silt recovery and water clarifying apparatus is placed outside the washery. It dispenses with settling ponds and manual labour for recovering the coal silt and delivering it to the boiler furnace for fuel.

"The dross or small coal, after being separated from the large coal by the shaking screens, is collected and delivered to the washer by a bucket elevator, and is then screened (usually) into five different sizes before being washed. From the revolving sizing screens it passes to the washers—the two smallest sizes, fine and pearl coal, being washed (freed from impurities) in the felspar washers, and the other three sizes—single, double, and treble nuts—in the Bash washers.

"In the felspar washers the impurities sink through a bed of felspar, and wire mesh supporting it to the elevator boot, which is common to the whole nest of felspar washers, usually arranged in

sets of three, so that the coal undergoes three washings. The elevator boot is connected watertight to the washers and to a watertight casing, inside of which the buckets move.

"The buckets are closely perforated, so that the water will drain off while they are travelling to the top, and the impurities or refuse so collected be discharged into a hopper practically free from water, from which it is taken to the waste heap. The action of these felspar washers is perfectly automatic, the coal, which rises to the surface, being continuously floated off by the water, while the impurities are also continuously being collected and discharged as described.

"The nut coals from the 'Bash' washers are also floated off by the water, and are separated from it by shaking screens or sieves, which also determine the final sizes of the nuts.

"The impurities from the coal, instead of passing through a bed of felspar (which is absent from the Bash washers), is discharged through a specially-devised outlet leading to an elevator similar to that described for the felspars, the collection and the discharge of the impurities being in this case also continuous and into the same hopper. The impurities sent to the waste heap seldom contain more than one per cent. of coal, and the washed coal not more than one to two per cent. of free dirt. All the water, including surface water caused by dripping from trucks, &c., after the nut and pearl coal have been separated from it (the pearls are recovered by the apparatus shown, and marked pearl recoverer), is run through pipes to the fine coal silt recoverer and water clarifier.

"The chief function of this apparatus, as its name indicates, is to prevent the possibility of any polluted effluent and to recover every particle of coal. In its action it resembles a dredger, the river's bed being represented by a long tank, which may be placed wherever convenient; along the bottom of this tank the buckets, carried by endless chains, move and collect the matter which has subsided there, the buckets being very long and closely perforated all over to allow the water to drain off but retain the solid matter till they reach the top, a height of 40 feet, when it is discharged into a shoot leading to the boiler stokehold or wherever desired without manual labour. From this apparatus the water is circulated back through the washer during the whole time of washing.

"After the washer is stopped for the day, the silt recoverer and water clarifier is kept moving very slowly until the solid matter is all recovered, and only that which is in suspension remains, but which, allowed sufficient time, gradually precipitates, and leaves the surface water clear, so that it may be run off at suitable intervals.

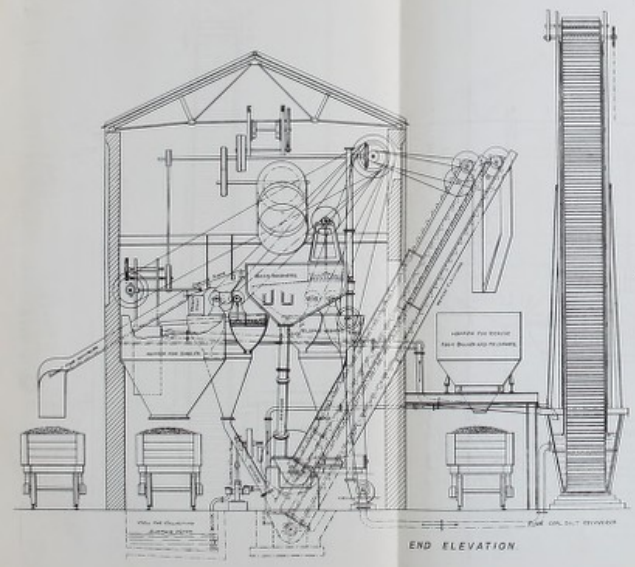
"The space left in the tank after this clear water has been run off is sufficient to hold the accumulation of the spray water used during the day for rinsing the nuts, and the water so used is usually what has been run off the previous night, so that there is no effluent, and settling ponds are not required.

"It will be understood from the foregoing that the quantity of

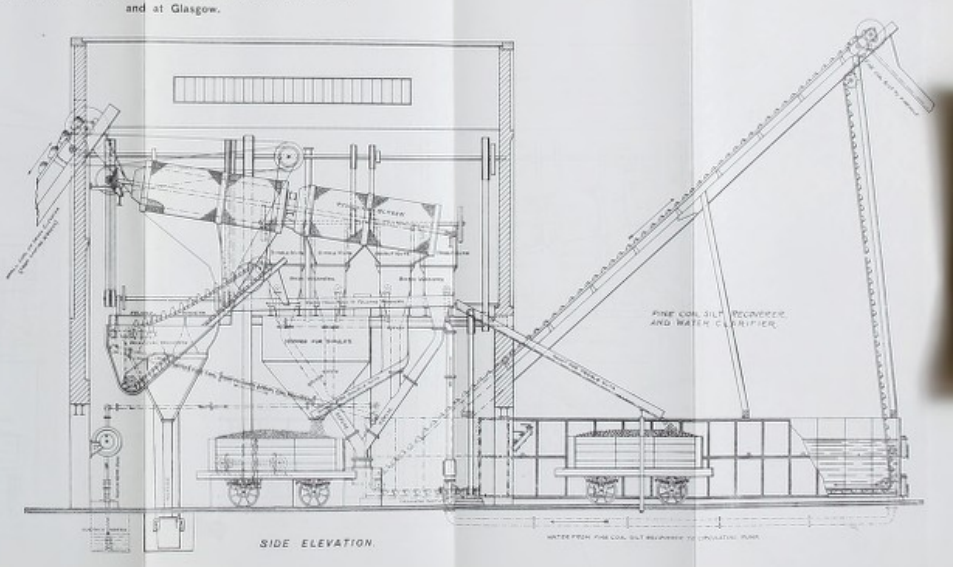
Arrangement of Coal-Dross-Washing and Sizing Plant

Made and erected by

Campbell, Binnie, & Co., Engineers, Burnbank, Lanarkshire,
and at Glasgow.



END ELEVATION.



SIDE ELEVATION.

water required to keep the washer working is very small, being only what is carried off by the coal, and the question of water supply may therefore be disregarded in considering the adoption of washing plant."

Another form of washer, patented in 1884, and largely adopted, might be mentioned. It is known as the Robinson or Hopper Washer, and consists of a large conical tank with revolving arms. All the small coal is first emptied into the washer, and freed from dirt by the agitation caused by the arms revolving in the water, and by the force of the pulsometer which supplies water by an inlet near the bottom of the washer. Thereafter the wet coal is taken to a screen to be sized. The dirt is released from the bottom of the washer, and is received into a waggon for removal to the refuse heap. The dirty water, with the smallest coal, is, at a few collieries, conducted to a silt recovery tank, as above described. Where this has not been provided, the amount of water used is very considerable, and the cleaning out of the settling ponds with shovel and barrow entails considerable expense.

From the foregoing it will be understood how the extent, and even the character, of pollutions from coal-dross washers depend largely upon the plant employed. There is reason to believe that the action taken by the County Council in the administration of the Rivers Pollution Prevention Acts has hastened the more general introduction of improved methods of washing, and especially the provision of plant for the recovery of the finest coal or silt. There are still, however, about 23 coal washers where no return system of dealing with the washings exists, and 41 where no silt recovery tank is used.

It has also been shown that the source of pollution arises mainly from the washers, and also as drip from the loaded waggons and sometimes as drainage from the silt. In one instance only has pollution occurred from the deposit of silt on the refuse heap, when during heavy rainfall it was washed into an adjacent stream.

The polluting character of Coal-dross Washings.—In the early period of the Council's administration the question was frequently asked—Can coal-dross washings be dealt with under the Rivers Pollution Prevention Acts? Yet this was one of the pollutions brought before the Royal Commission of 1868, and the evidence then obtained showed that this form of pollution was of a serious nature, affecting agricultural and other industries by rendering the water of streams unfit for use.

The *complaints* received in this county, and the investigations made, afford evidence of a similar nature. The farmer, whose

P10

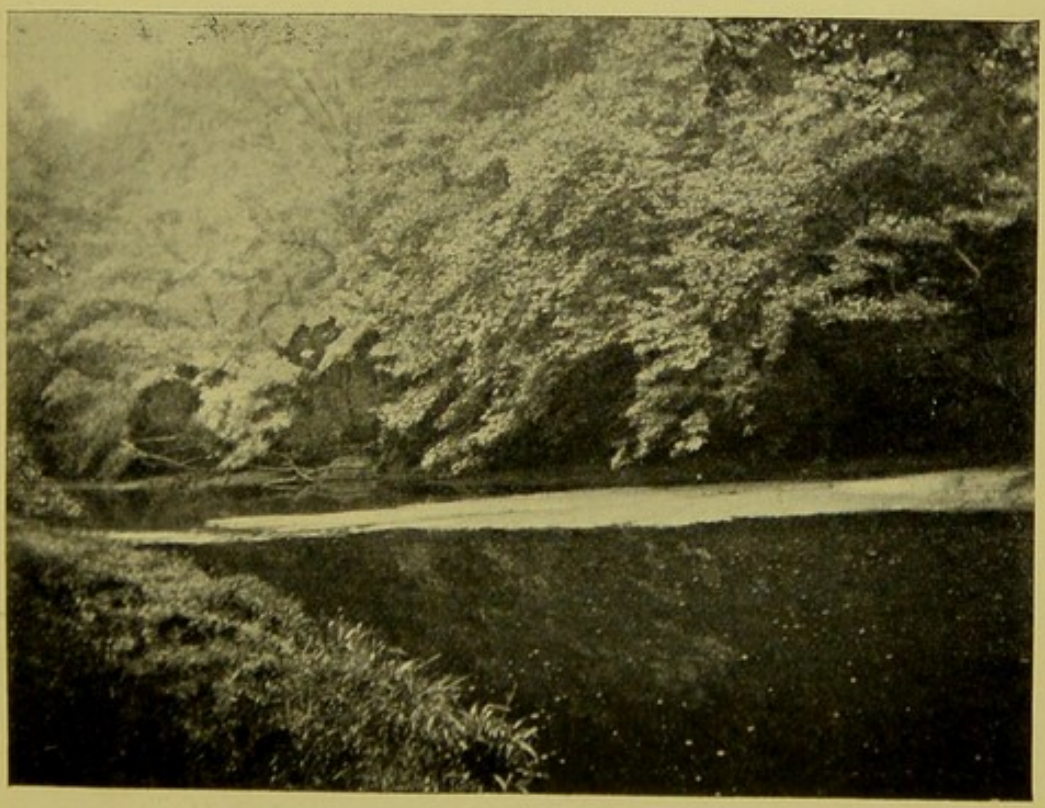
fields have been watered by a clear, rippling brook or ditch water, finds that dross washings render the water unfit for any purpose whatever. The grazing cattle either turn away from the black polluted liquid of the stream, or if thirst compels them to drink of it they seem to suffer afterwards, and damages have been recovered for losses alleged to have been due to this cause. From a farmer the following note was received about a year ago:—"I have to inform you that my sheep have suffered for years past through drinking water polluted with coal washings. One of them died this year; another has been attacked and is sick to-day. As the matter is urgent, a visit will oblige. I have the stomach of the one that died last beside me." The sickening sheep was dead when the Inspector arrived, but the stomach was removed and examined in the laboratory. The internal surface was found to be coated with coal and sand particles, which were removed by elutriation, and found to weigh about 4 ozs. This was no new experience with this farmer, as he assured me many such deaths under much the same conditions had occurred in his flock. The grazing field was watered by a stream found on several occasions to be seriously polluted by coal-dross washings. Farmers also seem to suffer during floods through such polluted streams covering portions of adjacent fields with a black deposit, which is seen after the water subsides.

From manufacturers complaints have not been numerous, but as an instance I might mention the case of a Turkey-red dyer whose works are situated about 1½ miles below the outfall of a coal washer. The water as pumped from the Clyde was found to contain so much fine coal and silt in suspension that serious damage was done to the dyed goods. This led to the introduction of filters at the dye-works, but even yet there seems occasional cause for complaint.

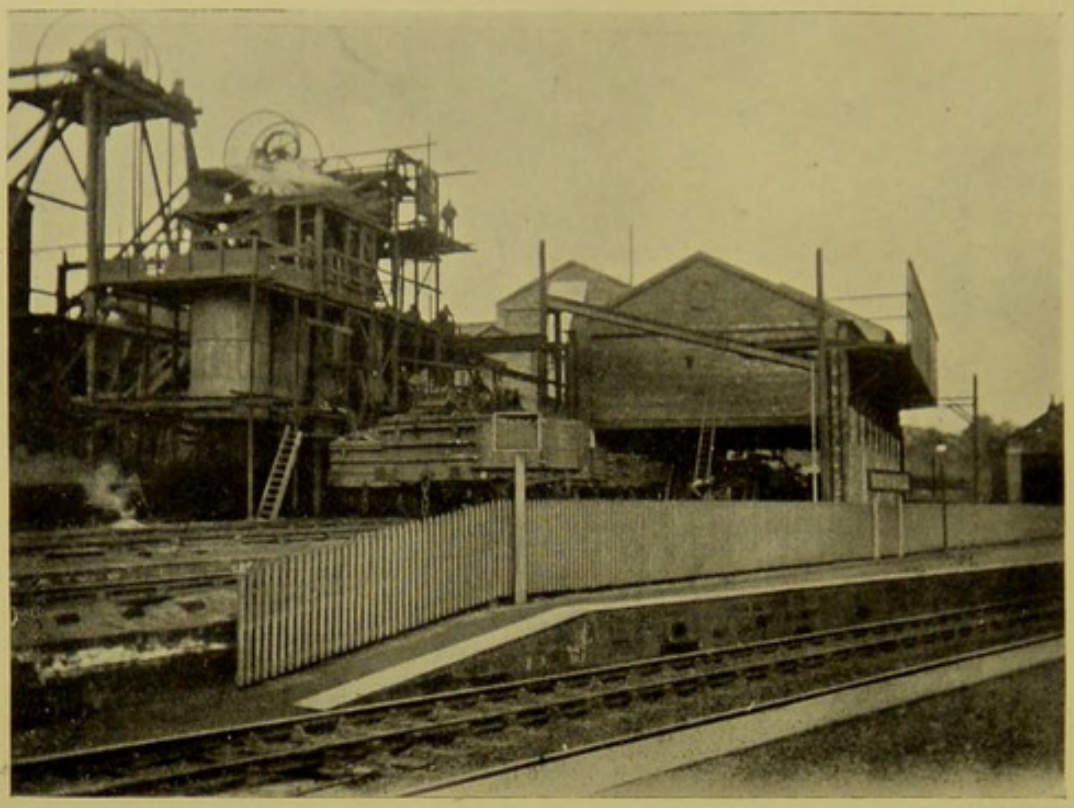
The numerous samples of coal-dross washings examined in the laboratory show some variation in character, but in every case the chief impurities are the suspended solids, consisting of clay, coal, &c. A sample containing only 30 grains per gallon of this suspended matter has a distinctly dirty, turbid appearance, yet some samples taken at the outfall into a stream have contained more than 1,000 grains per gallon. When a sample is allowed to stand for two hours or so the suspended solids subside, and form a deposit at the bottom of the vessel, the larger coal particles being lowest, and the very fine clay uppermost in the deposit. Regarding the effect of this form of pollution on fish life the report of the Commissioners on Salmon Fisheries states:—"The fine detritus of coal-washings may act as an irritant to the gills of the fish, and by forming a deposit on the river bed prevents

A view on North Calder Water showing Outfall from a Coal-dross Washer. The deposit of silt, interfering with "due flow" of the stream, appears white in the photographs.

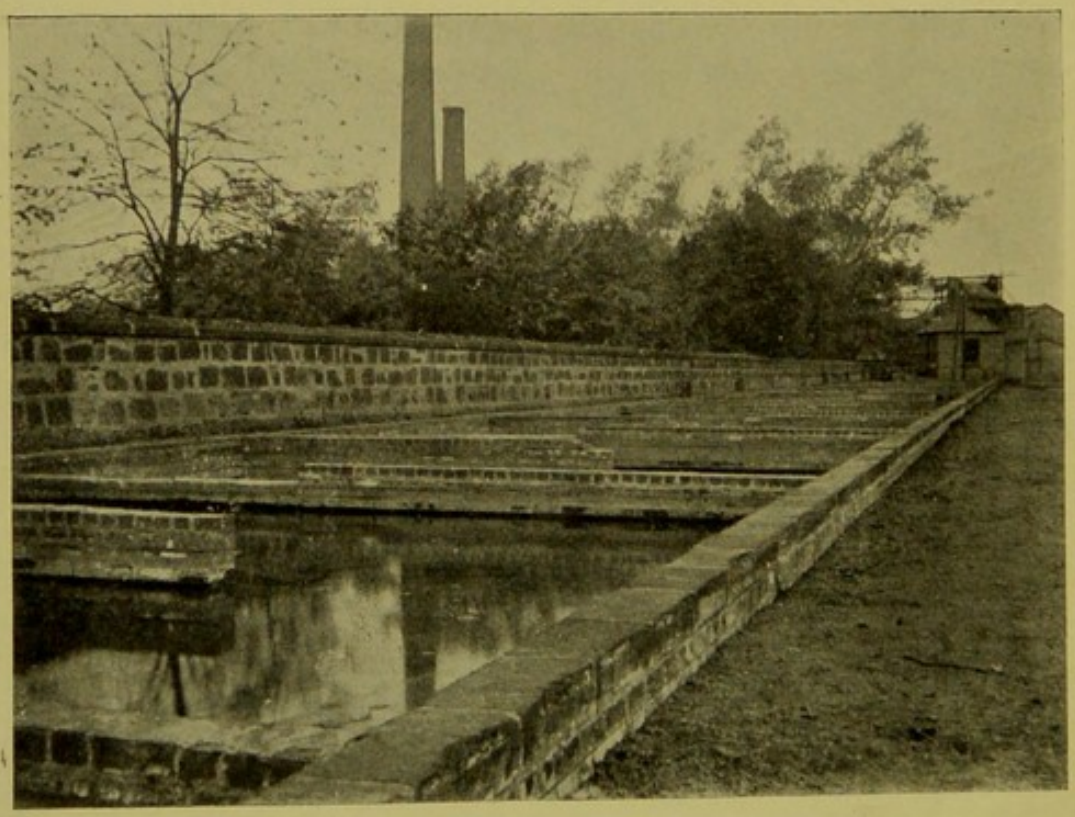
Looking down on the Coal-dross Washer Outfall.



Looking along the surface of the stream. The silt deposit is shown stretching right across the stream.



Colliery with Old Washer exposed to view, and New Washer erected, but not completed.



Series of Settling Ponds for Coal-dross Washings at the above Colliery.

the free passage of oxygen to the ova." The effect upon the bed and sides of a stream is seen long after the pollution has ceased, the black deposits giving a dirty appearance to the water. During heavy floods these deposits are carried away to be deposited at long distances from the point where the pollution arose, or they may be covered over by deposits of river silt. At one point on the North Calder the discharges from a coal-dross washer so silted up the bed of the stream as to constitute an offence under Part I. of the Statute by interfering with the flow—see illustration opposite page 52.

The prevention of pollution seems, on first consideration, such a simple matter, that the wonder is it should occur at all. Difficulties, however, soon become apparent when preventive measures are enforced. The difficulties relate to the provision of proper structural arrangements, their upkeep, and proper management. A colliery working a poor seam of dirty coal with an old washing plant, can perhaps ill afford to throw the old plant aside and provide the new machinery already described.

Settling ponds are essential in every case, especially where there is no return system and no silt recovery arrangements in the plant, and the area of land required is very considerable. Should the colliery be situated in moorland where ground is cheap, the necessary area may be obtained, and if the configuration of the ground be suitable, the ponds may be constructed at no very serious cost. But where the ponds are constructed of turf and clay, to which the deposits of silt are added when the ponds are being cleaned out, there is great danger during wet and stormy weather of the sides giving way, and the contents being carried direct to the stream. Serious pollutions have thus occurred. Consider also the labour involved in cleaning out these ponds, some of which have been known to contain from 50 to 100 tons of silt. At one colliery, where the ponds have a capacity of about 300,000 gallons, the manager stated that the cost of cleaning the sludge from the ponds amounted to about £150 per annum. In order, however, to reduce this cost, there has been provided a dredging-machine which removes the sludge continuously. Again, in some cases the colliery may be so situated as to make the acquiring of ground costly and difficult. In the illustration opposite this page, the colliery is bounded on two sides by a public road, on a third by a railway, and on the fourth by castle policies. Here the series of ponds constructed have involved considerable expense, and the matter of their emptying is not free from difficulty. At one or two collieries there are areas which have subsided through underground

workings, and to which the dross washings are conveyed in pipes and allowed to settle. The chief difficulty in this arrangement, however, lies in the danger of the pipes silting up. Leakages are also apt to occur, pollutions thereby taking place.

The expenditure incurred in the provision of means for the prevention of pollution by coal-dross washings, and the amount involved in their upkeep and management, is considerable. The latter might be put down at an average of £120* per annum for each colliery. The greatest expenditure is probably about £200 per annum.

Difficulties in detecting pollution are considerable. There is, no doubt, on the part of the employees at some collieries, wilful negligence or something worse. The inspector visits, he finds the washings being properly treated, but on examining the outfall and the stream below there is abundant evidence that serious pollution has occurred since his previous visit. The manager is appealed to, but a satisfactory explanation is seldom obtained. Inspections are then arranged for at unusual hours, and on one occasion an all-night inspection was carried out, when, at about two o'clock in the morning, the inspectors who were waiting down the stream found it being seriously polluted. On proceeding to the colliery, they found the sluice of the settling pond raised, and the contents of the pond entering the stream without any treatment whatever. The question may be asked as to what should be done to make the detection of offences more simple, and the provision of fines or penalties has been suggested. Probably a better arrangement still would be to have the outlets from all collieries so constructed that the washings would have to pass through a well, with a lock, the key of which would be in the possession of the inspector. This well, on being examined, would at once show whether any quantity of suspended solids had been allowed to escape. Some attempt at such an arrangement has been practised for some time by the inspectors sinking a wide-mouthed bottle in the bed of the stream below the colliery outfall. On several occasions such bottles have been found completely filled with suspended matter, although at the time of the inspector's visit no pollution was taking place.

As by far the greater number of colliery owners have endeavoured to prevent pollution, and to comply with the requirements of the Rivers Pollution Prevention Acts, it is unfair to those parties who are thus incurring considerable expense to allow others in the same trade to continue causing pollution.

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* Taking the total number of coal-dross washers as 68, the expenditure would amount to over £8,000 per annum.

Ammonia Works.

Under this heading are included various important industries in which plant is employed for the recovery of ammonia and other chemical products at one time allowed to go to waste. In the destructive distillation of coal within retorts at gas works, or of shale at oil works, and in the combustion of coal, &c., in blast furnaces for the manufacture of pig iron, there is among the gaseous products formed a considerable quantity of ammonia, which, when made into a salt (generally the sulphate of ammonia), is of considerable commercial value. This product is largely used as a fertiliser, and has been sold at as high as £20 per ton; at present it is said to yield the manufacturer about £11 per ton.

According to the Annual Report for 1901 of the Chief Inspector under the Alkali, &c., Works Regulation Acts, the quantity of salts of ammonia produced in Scotland during that year was over 75,000 tons. Of this quantity about 16,000 tons were produced at gas works; 16,000 tons at iron works; 40,000 tons at shale works; and about 3,000 tons at coke, &c., works. The works concerned in the production were 32 gas-liquor works, 15 iron works, 15 shale works, and 5 coke, &c., works. Of these there are at present situated in Lanarkshire — 4 gas-liquor works, 9 iron works, 1 shale work, and 2 coke, &c., works.

In the recovery of ammonia, water is used to wash the gases, and in doing so the water also absorbs other chemical substances of a poisonous character. After the ammonia has been removed from this liquid, these obnoxious substances remain, and the liquid then known as spent ammoniacal liquor, if allowed to escape into a stream, constitutes a serious pollution. In order, however, to understand the source and nature of the pollution, and the remedial measures necessary to prevent the same, a brief description of the process and plant employed is here given. The main purpose of the plant is to recover all products of commercial value.

Development of the Industry.—The recovery of ammonia seems to have been first practised at *gas works*, where condensers were necessary to purify the gases for illuminating purposes, and tar thus removed. At a later date scrubbers for washing the gases and recovering ammonia were introduced. These scrubbers seem to have been in general use about the year 1870. The liquor thus obtained at gas works was at first sold to manufacturers who had works specially constructed for the treatment of gas works' liquors (one of these works is situated at Coatbridge), but in recent years

not only the large gas works, but even many of moderate size, have introduced an ammonia plant to deal with the liquor on their own premises. At *shale oil works* also plant for the recovery of ammonia has been in use for many years, but there is only 1 shale oil work in the County of Lanark, and only 2 coke or gas-producer works.

Although *blast furnaces* on a large scale have been in operation in this county for more than a century, it is only within the last twenty years that manufacturers of pig iron have endeavoured to utilise the gaseous waste products, which were previously allowed to escape into the atmosphere and illumine the district around the works. The first plant specially designed for the recovery of the by-products was planned and erected by two members of the firm of Messrs. Wm. Baird & Co., viz., Mr. John Alexander and Mr. Andrew K. M'Cosh. This plant was erected at Gartsherrie Iron Works in 1881, and the process then adopted is the same in principle as that in use at the present day in plant of recent construction. In 1884 modifications of the above process were tried at other works, but have since been abandoned. Up to 1886 the recovery of by-products from blast furnace gases might be said to have had a struggling existence, but about that time a market was created for the sale of the oil recovered by the invention of two special lights, known as the Lucigen Lamp and the Well Light. The demand for the oil assumed such commercial importance that it led to the gradual adoption of chemical works for the recovery of by-products at all the blast furnaces in Lanarkshire.

From the foregoing notes it will be understood that, so far as the County of Lanark is concerned, the ammonia plant connected with blast furnaces is by far the most important from a rivers pollution prevention point of view. It will, therefore, be sufficient, in considering the process and plant employed, if a description be given of the arrangements at blast furnaces.

Plant and Process.—The process is, first, cooling the gases, when the less volatile substances—such as tar oil, &c.—condense, and then washing the gases, when the more volatile substances—chiefly ammonia—are carried off in solution. In every plant the control of the gases is effected by a hood at the top of the furnace, where there is a cylindrical tube from six to nine feet in diameter, which the gases enter, and along which they are directed to the various parts of the chemical plant. These comprise a dust box and a primary washer, condensers, exhaust fan or engine, and engine house, ammonia washers and scrubbers. Throughout all this plant the gases are within air-tight structures, and cannot escape. Subsidiary to the main plant there are the sulphate of ammonia

plant, tar stills, and pitch ponds. The engine house is situated about the centre of the plant, and by means of powerful steam engines the whole of the gases are first drawn towards the exhaust box, and from there propelled onwards until they reach the stoves of the blast furnaces where the remaining gases are consumed.

The gases leave the furnaces at a very high temperature, probably about 400 degrees Fahr., and carry with them dust particles of various constituents. The heavier of these particles fall into wells formed by branch tubes known as "down-comers." In order to free the gases completely from dust particles they first enter the dust boxes, sometimes called the primary washers. Here the velocity of the gases is impeded by baffle plates and a liquid seal. In the dust boxes the greater portion of the tar, say, 80 per cent., condenses, and is run into a storage tank. No pollution has been known to occur from this part of the plant.

The gases then pass to the condensers, which consist of a series of vertical tubes about 50 or 60 feet high and about 20 inches in diameter. These tubes are at the bottom connected with a large iron tank, sub-divided so as to form a series of compartments with about ten tubes in each compartment. At the top the tubes are connected in pairs, the whole being so arranged that the gases entering one compartment pass up one series of tubes and down another into the next compartment. The total length of tubes in a set of condensers is very considerable, and varies at different works according to the amount of gas to be treated. In this part of the plant the gases are so much cooled that the remaining tar and all the oil condenses. This liquid flows from the iron tank into a separator, where, according to the specific gravity, separation of the oil from the tar takes place. The gases before leaving the condensers must be cooled to a temperature not exceeding 65 degrees Fahr. Should this temperature not be reached a spray of water is played on the surface of the condensers. This generally requires to be done during summer and autumn weather. The water from the sprayer collects near the bottom of the condensers on the top of the iron tank and is used over again, being raised by a steam pump. When there is much wind some of the spray is driven past the condensers on to the ground surface, which is often in a polluted state. The fallen spray carries off these impurities and may constitute a source of pollution.

The gases after passing through the condensers enter the exhausters at the engine house, where they are forced onwards to the washers, which consist of a series of horizontal iron boxes fitted with perforated plates and filled with liquid, the source of which will be

explained. The gases entering at the middle of the washer are forced through the perforations, and part with a considerable portion of the ammonia to the liquid, which is then known as ammoniacal liquor. This liquor, or solution of ammonia, is run off by suitable valves to the separator, and then to the stock tank.

On leaving these washers the gases are forced through scrubbers. These are towers built of iron, and about 120 feet high. They are so constructed that a continuous spray falling from the top of the tower becomes so intimately mixed with the gases that almost all the ammonia they contain is removed. In some recent plants the scrubbers have been replaced by final washers of horizontal construction.

For the third or last scrubber clean water is used, while for the other two scrubbers liquor is raised from the stock tank. The liquor from these towers passes to the washer already described. The gases, having now been deprived of tar, oils, and ammonia, are ready to be utilised for heating purposes throughout the works. Thus they are conveyed in tubes to the steam boilers and to the tar stills, where they are ignited, and take the place of ordinary fuel. The remainder of the gases are led back to the blast furnaces, where they are used for steam raising and heating the hot blast stoves, which heat the air as it is blown into the blast furnaces.

The plant for the manufacture of sulphate of ammonia is situated in an adjoining building, and consists of *superheaters*, which heat the liquor and tend to volatilise the ammonia, *stills* in which the liquor, in a state of fine sub-division, meets with a current of steam which carries off the ammonia vapour to the *saturator*, where it passes through sulphuric acid, forming sulphate of ammonia, which, on separating out in the saturator, is removed to a drainer. The liquor raised from the stock tank and deprived of ammonia in the stills passes away from there as spent ammoniacal liquor, and constitutes the chief source of pollution.

The tar which has been collected is seldom sold in liquid form, but is made into pitch by distilling off some of the oil it contains. It is therefore raised to the tar stills, where the oil is driven off by heat and condensed, while the tarry liquid is run off from the bottom of the still into large shallow ponds, where, on cooling, it solidifies, forming ordinary pitch. As these ponds are not covered, they require drainage outlets to carry off the rainfall, and this may prove another source of pollution. The whole surface of the ground at such works is liable to be more or less polluted with tar oil, so that during rainfall the surface drainage from the works, generally, may cause pollution.

Spent Ammoniacal Liquor.—The liquor deprived of ammonia is no longer of any value to the manufacturer, although it contains poisonous substances such as phenol and cresols, and, as it is produced in considerable volume, it constitutes a source of serious pollution. Analysis of samples collected from time to time at outfalls from works in connection with pollutions show that the strength or poisonous character of this liquid varies considerably. This is mainly due to the drainage arrangements at the works, as the liquor itself is fairly constant in composition. Thus, a sample of ammoniacal liquor taken at an iron work before it goes to the sulphate plant was found to contain 310 grains of phenols and about 500 grains of ammonia per gallon. A sample of liquor taken after it had passed through the sulphate plant and had become spent liquor contained 280 grains of phenols and less than 20 grains of ammonia per gallon. A sample of spent liquor taken at shale oil works contained 112 grains of phenols and fully 20 grains of ammonia per gallon. A sample of spent liquor taken at a gas work contained 439 grains of phenols and about 24 grains of ammonia per gallon. In connection with pollutions a large number of samples taken at drainage outfalls from ammonia works have also been analysed, and the *average results* of several series are given in the following table :—

[OVER.

TABLE D.—SAMPLES, TAKEN AT DRAINAGE OUTFALLS FROM AMMONIA WORKS, CONTAINING SPENT AMMONIACAL LIQUOR. THE AVERAGE ANALYSES OF THE SAMPLES ARE STATED AS GRAINS PER GALLON.

SAMPLES TAKEN.	CLYDE IRON WORKS.					CARNBROE IRON WORKS.
	Nov., 1901.	Nov. 1901.	July and Aug., 1902.	Aug. and Sep. 1902.	Feb. 1903.	Oct. and Dec. 1902.
Ammonia—Free, ...	0·23	...	0·46	0·87	0·12	1·31
Do. Albuminoid, ...	0·24	...	0·13	0·39	0·07	0·08
Oxygen absorbed, ...	68·45	47·72	119·8	201·3	3·24	7·7
Phenols, &c., estimated by bromine process, ...	...	...	110·1	220·0	2·60	4·1
Phenols or Acid Tar Oils,	18·56	...	...	...	...	...
Other Oils, ...	2·19	...	...	...	...	...
Total Tar Oils, ...	20·75	17·37	...	...	...	...
Physical Characters, ...	Reddish-brown in colour.	More or less of a dark reddish-brown colour; distinct odour of carbolic compounds; abundance of suspended matter, which sedimented on standing.	Fairly transparent; colour varied from yellow to amber; turbidity from none to distinctly turbid; odour of tar oils; deposit varied from none to distinct granular.	More or less transparent; colour yellowish-brown or amber; not turbid on standing; slightly turbid on shaking; odour of tar oils; slight granular deposit.	Fairly clear and transparent; reddish-brown colour; medium odour of tar oils; small dark deposit, slightly turbid on shaking.	Clear and transparent; reddish-brown colour; medium odour of tar oils; medium brownish deposit, rather turbid on shaking.

One very striking result in these analyses is the large amount of oxygen consumed by the permanganate oxygen process and the comparatively small amount of albuminoid ammonia yielded, showing that the oxidisable substances are carbon compounds. This probably explains why fish cannot live in such liquids, even when largely diluted with clean water.

In routine laboratory work, when a large number of samples have had to be examined, a very reliable indication of the amount of noxious substances present can be obtained by the oxygen process alone. In a series of 22 samples taken during 1901 at one outfall from Clyde Iron Works the amount of oxygen absorbed varied from 10 grains to 73 grains per gallon. It will be observed that in the analysis of the first two series of samples given in the table the phenols were not estimated by the bromine process, but the amount of acid and other tar oils was determined, after extraction, by ether. These series of samples were examined by Dr. Clark, Public Analyst, and Professor Glaister, in connection with a court case in which they gave evidence. The direct estimation of the poisonous substances in spent liquor is not free from difficulty, but probably the determination of the phenols by the bromine process is the most reliable method. Of indirect methods the estimation of oxygen consumed is most valuable.

In the last two series of samples it will be observed that the amount of phenols was very small, and probably represents surface drainage from the works, as at each of these places when the samples were taken all the spent liquor was being evaporated. The extent of pollution was, however, very different in each case. At Carnbroe Iron Works the bulk of the drainage is collected in a tank and evaporated. The amount of polluting liquid escaping at the outfall was very small, and might have been conveyed in a 2-inch pipe. In the other case, Clyde Iron Works, the sample was taken at the main drainage outfall, where a very large volume of water escapes, and is known as tuyere water, because it is used at blast furnaces in cooling the tuyeres protecting the hot blast pipes. Having regard therefore to the quantity of polluted liquid escaping at this latter work, the pollution indicated by the analysis must be considered serious. These two series of analysis show that even the drainage from ammonia works receiving no spent liquor may cause pollution.

The poisonous character of spent ammoniacal liquor is easily demonstrated by its effect on fish life, and was shown in the first serious pollution to which my attention was called. This was in January, 1896, when the discharges from Clyde Iron Works so

affected the River Clyde that the polluting liquid could be traced for a long distance, and several dead fish were found on the river banks below the outfall. In April, 1900, when a similar serious pollution occurred from Carnbroe Iron Works, the North Calder was affected for several miles. The samples taken were tested in the laboratory as to their effect on fish life, and were found to kill minnows in a few minutes, even when diluted with water.

The complaints received have all shown the polluting effect to be of a distinctly poisonous character. Thus, a sheep-grazing farmer, through whose lands a stream receiving discharges of spent liquor from a shale oil work flows, alleged that many of his sheep had died from drinking the water of the stream, and it is the case that since preventive measures have been adopted at the work concerned no complaints have been received.

The prevention of pollution generally requires that no spent liquor should enter a stream, since no means have yet been devised of purifying spent liquor by removing its poisonous constituents. It seemed to me that this liquor might have been used as a disinfectant, especially for flushing sewers and such like work, and a sample was forwarded to Messrs. F. C. Calvert & Company, who prepare such large quantities of carbolic acid for the market. I was, however, informed that such ammoniacal liquor would be of no use to them.

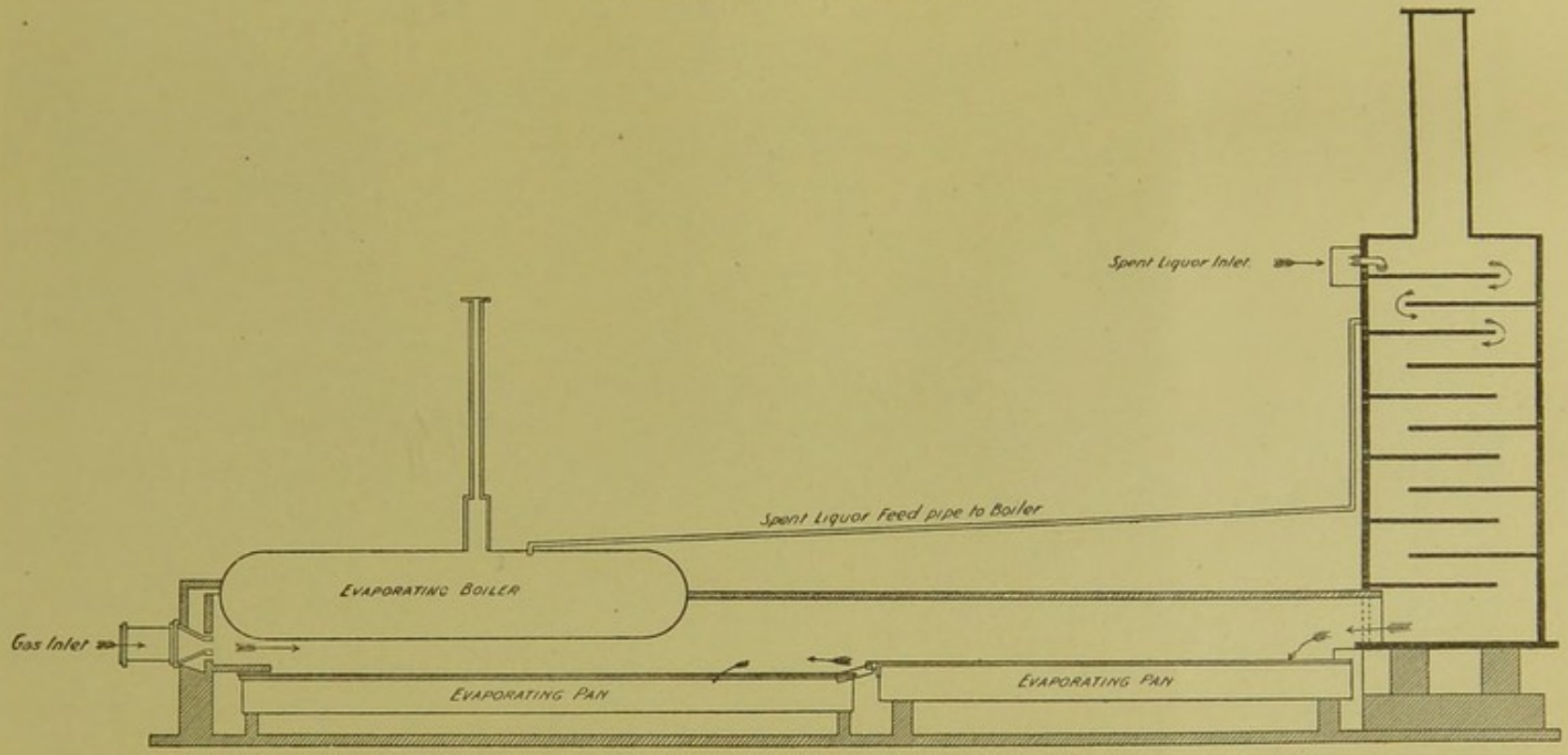
Some method of evaporating the spent liquor has been generally adopted, although at some works they are fortunate in having a disused mine, into which the liquor is discharged. In the subjoined Table E the means adopted for preventing pollution at each of the ammonia works are briefly indicated. Some method of evaporation is in use at ten of these works, and at other five a disused mine is convenient. The gas-liquor works at Coatbridge drain into the burgh sewers.

The means of evaporation vary. At three iron works and at one small coke work the spent liquor is utilised in the ordinary boilers for raising steam. The combustible gases are led to the fire box, where they are ignited, and serve the purpose of ordinary fuel. The sediment which forms in the boiler requires to be properly sludged out, and a tank is provided to receive the sludge as it is blown off. As phenols volatilise with the steam, the ground at such works tends to become saturated with phenols where the exhaust steam condenses. At two iron works a special plant has been constructed, by means of which all the spent liquor is evaporated in pans by the combustible gases.

At one of the iron works there is also an arrangement for reducing the amount of spent liquor produced, by means of a "Klein" cooler, which enables spent liquor to be used over again.

AMMONIA WORKS.—SPENT LIQUOR EVAPORATING PLANT.

DIAGRAMMATIC SECTION.



Ammonia Works.—Spent liquor evaporating plant.

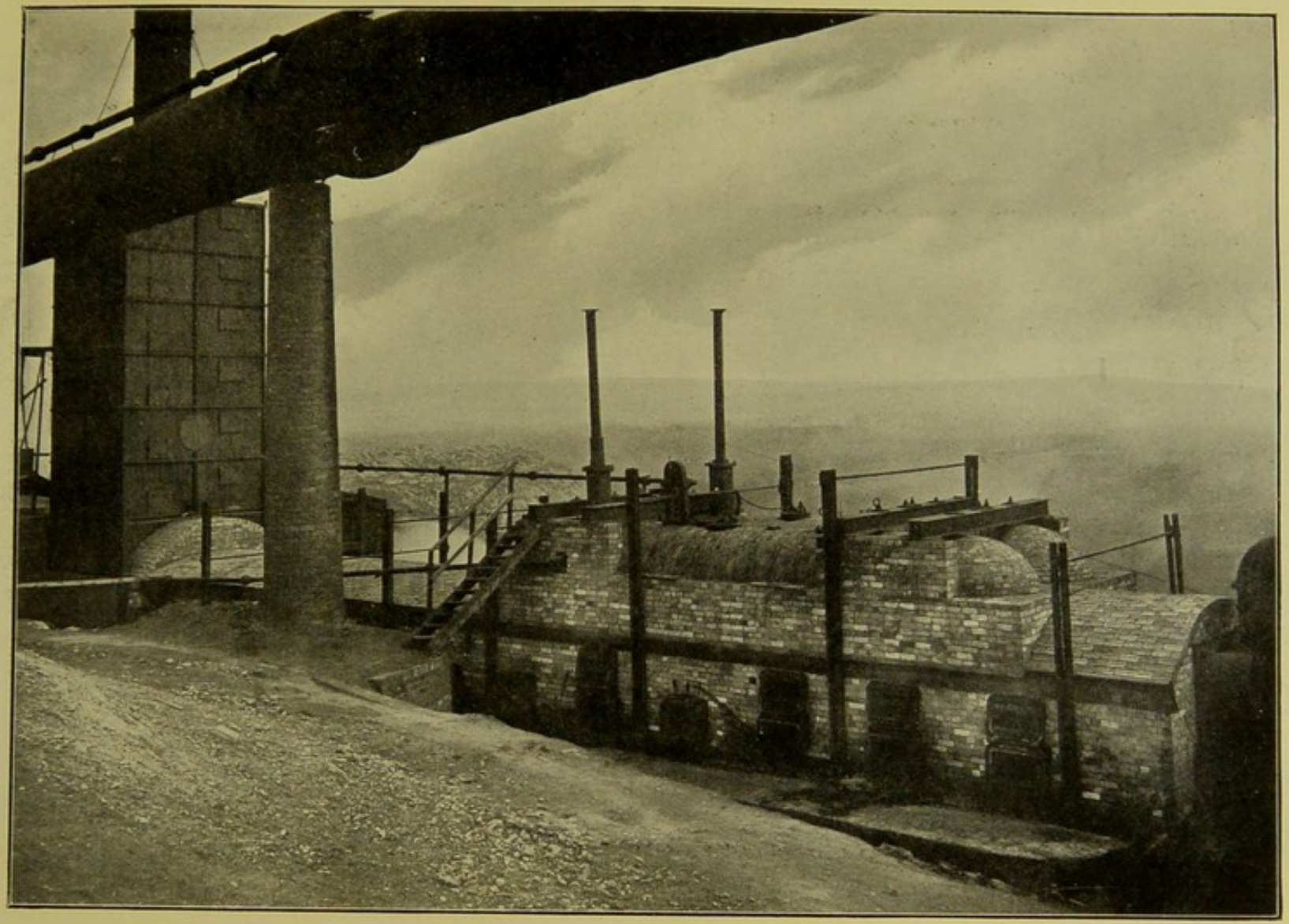


Photo. showing front elevation of Evaporator.

Ammonia Works.—Plant known as "Klein's Cooler."

Spent liquor cooled and used over again.

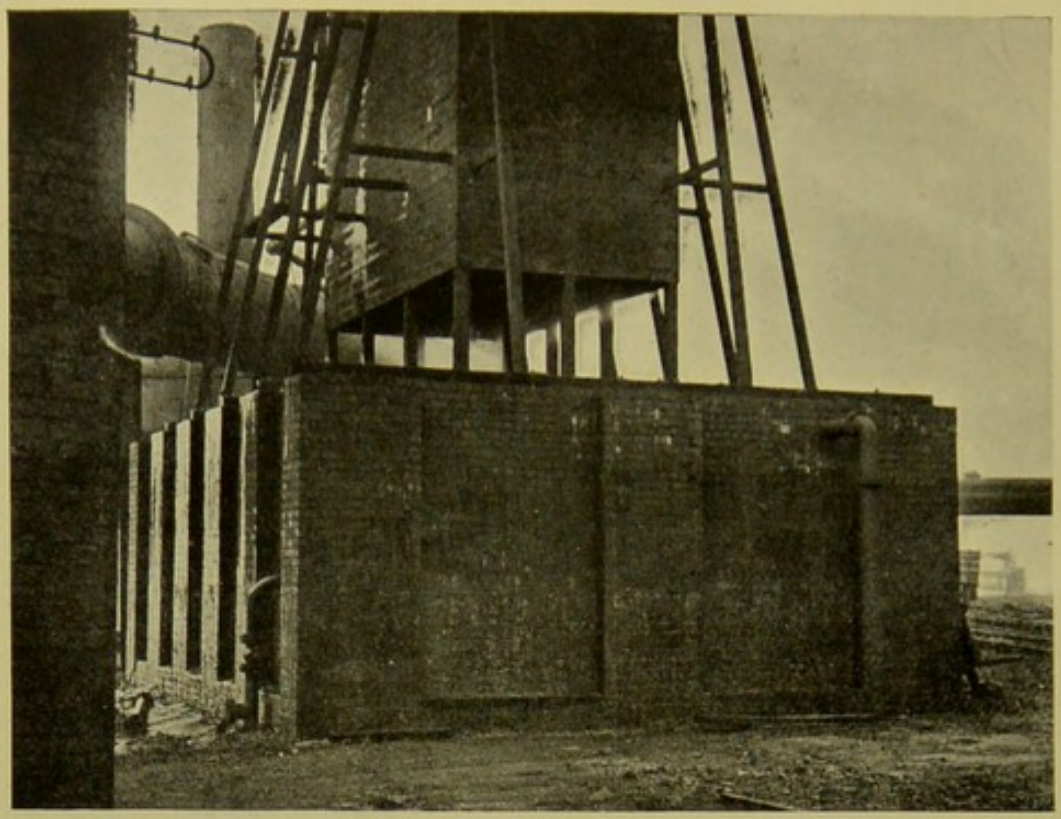


Photo. showing the collecting tank at the base of the cooler.

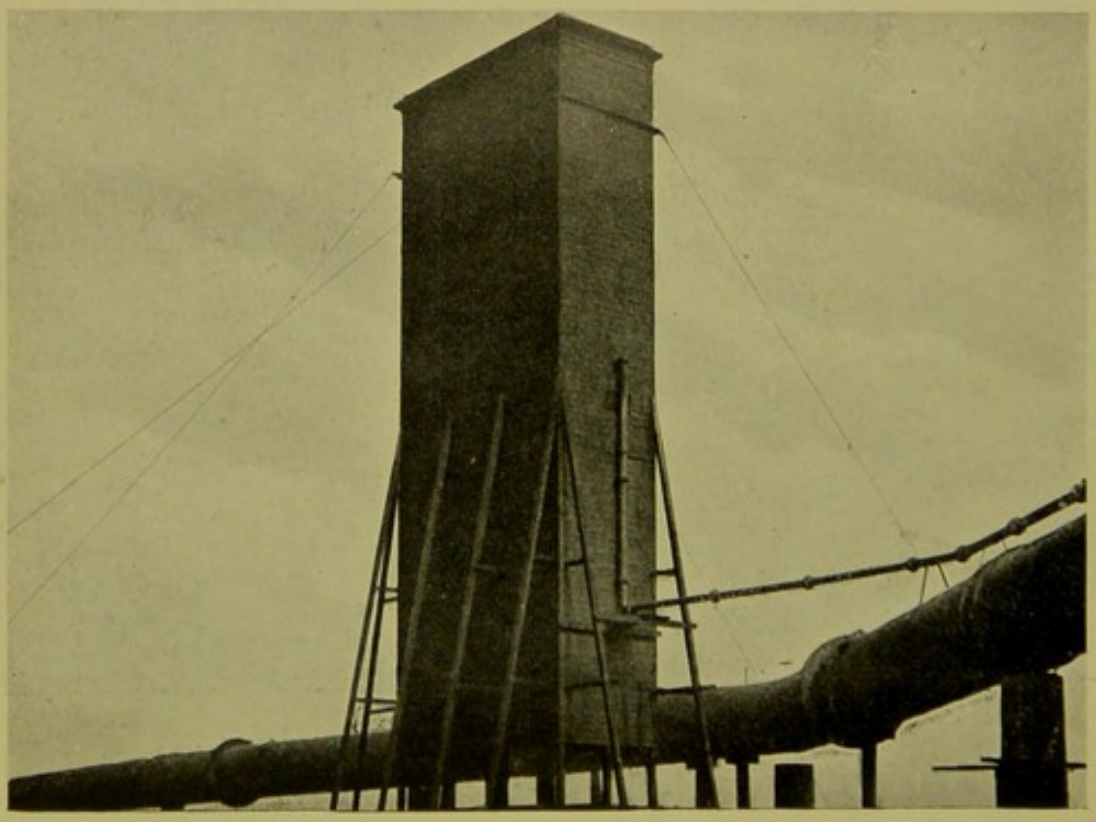


Photo. showing the tower in which the liquor is sprayed and cooled.

At the three gas works the method of evaporation is very simple. The hot coke, as drawn from the retorts in barrows, is placed underneath a tank containing spent liquor, which is sprayed on the coke to extinguish it. The liquid falling from the coke is collected in a well where, by settling, it is deprived of any particles of coke washed away. This liquor then flows back to the collecting tank, from whence it is again raised by a pump to the spraying tank. I am informed that the amount of evaporation obtained in this way is sufficient to prevent the stock of spent liquor from accumulating.

A similar method of evaporation is employed at the shale oil works. The spent liquor is forced in pipes to the top of the shale bing, where part of it is evaporated on the hot spent shale; the remainder percolates through the spent shale. The effluent escaping from the foot of the shale bing is small in amount, and the samples analysed have not shown any trace of phenols, although they are rich in saline material dissolved out from the spent shale.

TABLE E.—AMMONIA WORKS, WITH NOTE OF MEANS ADOPTED FOR PREVENTING POLLUTION.

No.	Name of Work.	Means adopted for preventing Pollution.
1	Clyde Iron Works, - -	Special evaporating plant.
2	Calder do., - -	Liquor discharged into disused mine.
3	Carnbroe do., - -	Liquor utilised in ordinary boilers for raising steam.
4	Shotts do., - -	Do. do.
5	Coltness do., - -	Special evaporating plant.
6	Gartsherrie do., - -	Liquor discharged into disused mine.
7	Summerlee do., - -	Do. do.
8	Langloan do., - -	Do. do.
9	Wishaw do., - -	Liquor utilised in ordinary boilers for raising steam.
10	Coatbridge Gas Works, - -	Liquor evaporated on hot coke as drawn from retorts.
11	Hamilton do., - -	Do. do.
12	Bothwell and Uddington Gas Works, - - - -	Do. do.
13	Gas-liquor Works, Coatbridge,	Liquor discharged into sewers.
14	Tarbrax Shale Oil Works, -	Liquor partly evaporated on hot "spent" shale, and partly dissipated by filtering through waste heap.
15	Shettleston Chemical Works, -	Liquor discharged into disused mine.
16	Millburn Chemical Works, -	Liquor utilised in ordinary boilers for raising steam.

Paper Mills.

The manufacture of paper is carried on at four different works. Two of these are owned by one firm, and are situated on the upper reaches of the North Calder Water. The other two are situated on the lower reaches of the Clyde in Rutherglen Parish, and are included in the area of the Glasgow South-side purification scheme. Although this scheme will not be completed for some years yet, the only question that has been considered regarding the prevention of pollution is as to whether any of these works will require to carry out, on their own premises, some preliminary treatment of the trade refuse before it is discharged into the public sewers.

The two works situated on the upper reaches of the North Calder are of considerable size. They are known as Caldercruix and Moffat Paper Mills. At both places the raw materials chiefly employed are wood pulp and rags. The wood pulp requires no special preparation, whereas the rags require a considerable amount of treatment in making them into pulp. In the manufacture of paper, other materials are added to the pulp, such as alum, clay, and dye stuffs. In order to understand the chief sources of pollution a brief description of the process may be given.

In the preparation of pulp from rags the processes might be classified as rag sorting, cutting and dusting, boiling and washing, breaking and bleaching (half pulp), beating (pulp), and paper drying and rolling. No pollution arises in connection with the first two processes.

Boiling and Washing:—At Caldercruix, the assorted rags taken from the stores are put into large boilers, and to the water caustic soda or lime shells are added. After boiling, the liquid is run off into drains leading to a pond outside the works. The bottom of the pond is formed of earth and ashes, through which the liquid filters before it reaches the stream. Occasional pollution has been detected from this source.

Breaking and Bleaching:—The rags brought from the boiling house are washed with clean water in troughs. After this clean wash they are taken to the breakers where they are reduced to a fibrous condition termed half pulp, and at the same time are bleached by means of chloride of lime, which is added to the water until a satisfactory result is produced. The liquid from these machines and from the preliminary washers goes direct to the settling ponds and filter area.

Beating Pulp :—After the half pulp has been drained and pressed to get rid of superfluous liquid it is put into the beating machine, where it is beaten into a very fine pulp. The other ingredients which enter into the composition of paper are now added.

Paper Machine :—The finished pulp is conveyed through a series of strainers, on to a wire-woven web, and then passes over rollers and hot cylinders. The drainage from the pulp on the web and rollers is partly caught in suction boxes and used over again, while a considerable quantity goes direct to the settling ponds.

For the prevention of pollution a large series of settling ponds and a filter area were constructed at considerable expense about the year 1895. Each pond measures about 56 × 14 × 5 ft. and holds about 24,000 gallons, and as there are eight of these settling ponds in the series their total capacity will be about 192,000 gallons. These ponds are connected at one end by a carrier or feed channel into which the liquor flows. They can therefore be used separately or in series as occasion requires. At the other end of the ponds the liquid after settling escapes by an outlet pipe into the stream, or overflows into the filter area. The sludge deposited in the ponds is of a pulpy nature, and is run off periodically by a sluice at the end of each pond, thence carried along a brick channel to to the sludge pond, where it is allowed to dry and is afterwards removed in hand-barrows to waste land.

At Moffat Paper Mills wood pulp is chiefly used, and when rags are occasionally required they are brought from Caldercruix Mills already prepared for the breaker, otherwise the processes are much the same as those above described. In addition, however, a considerable quantity of dye stuffs is used in the production of coloured paper. The chief sources of pollution are the wire-woven webs and paper making machines.

For the prevention of pollution the plant originally constructed consists of a settling pond, with a capacity of about 312,500 gallons, and a filter area with a total capacity of about 79,000 gallons.

Owing to complaints of pollution, new purification plant was recently introduced consisting of a collecting well and pump, settling tanks, sludge well and pump, and filter presses.

Settling Tanks :—From the collecting well the waste liquor is raised to the settling tanks (thirteen in number) arranged on either side of the building in two series. Ten of the tanks measure 8 × 8 × 6 ft., and three measure 12 × 8 × 6 ft., giving a

total capacity of about 35,000 gallons; each tank has a wooden division which does not reach the bottom. There is also an outlet valve at the bottom for sludge, and a moveable arm for drawing off the clear water. On the top of the tanks are wooden shoots conveying the waste liquor, which can be discharged into any of the tanks. Generally a number of the tanks are in use at one time, and the different coloured liquors are kept separate. After a tank has been filled the liquor is allowed to rest for three or four hours, then the surface water is run off to the stream. Afterwards the sludge valve is opened and the remaining contents discharged along an open concrete channel to the sludge pits.

Sludge Pits and Filter Presses:—Situated above the sludge pits is a steam pump which raises the contents to two filter presses situated in another part of the building. These presses are filled under a pressure of from 120 to 150 lbs. per square inch, and are of the usual construction, each press having 28 divisions. After the liquor has been *pressed* from the sludge, the solids recovered are stored, and the material thus collected is considered of sufficient value to meet a considerable portion of the expense of working the purification plant.

The greater portion of this plant has been in operation for more than a year, and has given such satisfaction that the remaining portion is being completed. The old ponds and filters situated outside the works have a total capacity of about 390,000 gallons, and will still be retained.

Print, Dye, Bleach, and Finishing Works.

The industries to be discussed under this heading might be enumerated thus. Bleach, dye, and finishing works, 3; dye works, 2; bleach and dye works, 1; print and dye works, 1. Two of the bleach and finishing works and the two dye works are situated in Rutherglen Parish within the area to be included in the Glasgow South-side sewage scheme. The other bleach and finishing work is situated at Carmyle, where the effluent discharged has not given rise to any serious pollution. The operations are more of a finishing than a bleaching process. It will, therefore, only be necessary to consider the last two mentioned works.

The print and dye works are situated at Glengowan in New Monkland Parish, and are known as Glengowan Print Works. The trade processes are numerous and elaborate. The works comprise bleach house, print house, dye house, and a colour house.

In the *bleach house* the cloth goes through some twelve different processes, and is alternately treated with different chemicals, such

Settling Ponds for Trade Effluents.

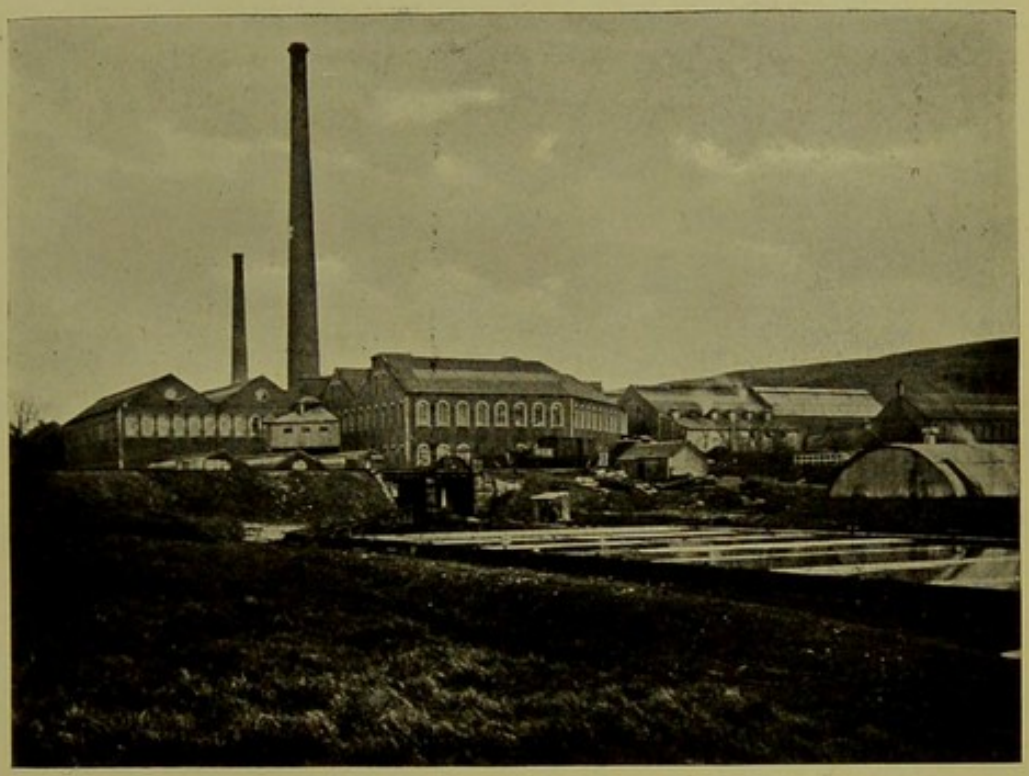


Photo. showing Caldercruix Paper Mills.

Settling Ponds for Trade Effluents.

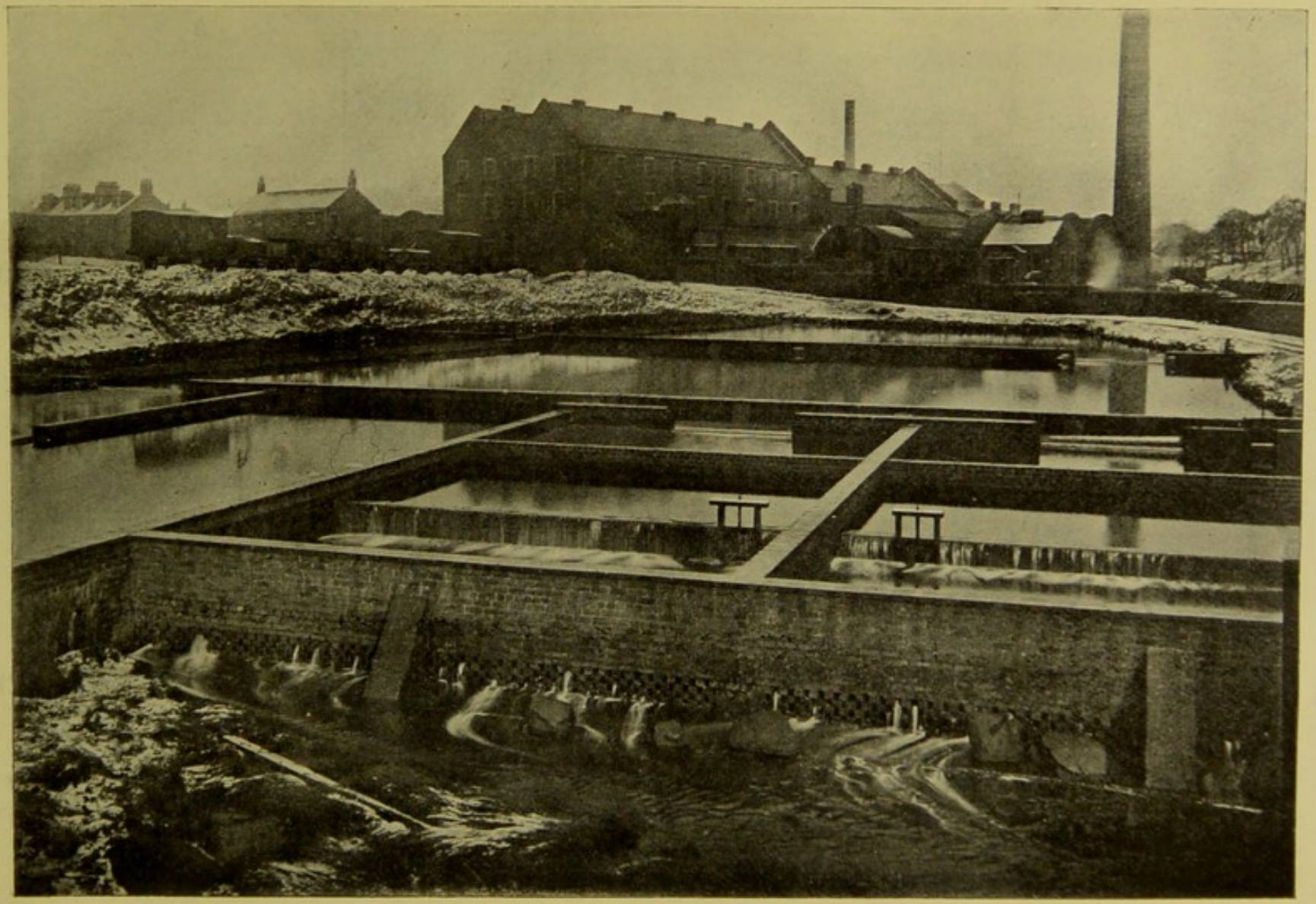


Photo. showing Glengowan Print Works.

as chloride of lime, soda ash, and hydrochloric acid. All the waste liquor discharged from the bleach house is conveyed to a collecting tank, thence it is raised by a pump and mixed with the dye-house liquors aftermentioned.

In the *printing house* are a number of printing machines and washing troughs. The drainage from this house consists chiefly of washings from dye boxes, brushes, and printing cylinders. These washings are highly coloured with dyes, and are led direct to the series of settling ponds and filters to be afterwards described.

In the *colour house* all the various dyes are prepared, and the drainage consists of washings from dye pans and vessels used in mixing and preparing the dye stuffs. Like the former, this liquid is led direct to the ponds and filters.

In the *dye house* the process consists of mordaunting and dyeing in addition to washing operations, and here the greatest quantity of coloured liquor is produced. The drainage goes first to a separate pond where sulphate of iron and lime are added. The liquor then passes to the series of settling ponds and filters, but on the way receives the liquor from the collecting tank first mentioned. Altogether there are nine ponds in use at these works, their total capacity being 550,000 gallons. There are also six filters in two series. Each filter measures $24 \times 16 \times 6$ ft., and the filtering material is engine ashes. The liquor passes from one pond to another, finally through the filters, and discharges into the North Calder. (See analyses of samples taken on 5th March—Appendix, Table X.)

Avonbank Bleach Works are situated on the banks of the Avon (the water of which is used for motive power), near Larkhall, in the Parish of Dalserf. The waste liquor from the bleach house is of considerable volume, and drains into a settling pond excavated in the soil, and having an area of about 195 square yards. The draw-off from the surface of the liquor is automatic, and is connected with a pipe which leads to the mill-race. The pipe, where it passes over the mill-race, has perforations on the under surface, and the liquor is thus discharged into the water in a fine spray.

At these works there is also a dye house. This, however, is not in continuous use, and the waste liquor is limited in quantity. This coloured discharge is led to a storage tank, but on the way is brought into contact with sulphate of alumina, so that precipitation takes place in the tank. The outlet from the tank is controlled by a valve, and the liquor is discharged not oftener than once a week into the pipe above referred to, so that it also finds its way into the mill-race in the form of a spray.

Oil Works and Chemical Works.

The only oil work included under this heading is concerned not with the manufacture of crude oil, but with refining only. Situated near Lanark, it is worked in connection with the shale oil works at Tarbrax already referred to. There is little effluent discharged from these works, and no pollution has been detected. The arrangements for the prevention of pollution are somewhat as follows :—

Acid and caustic soda are used in the refining process. The waste liquid is first caught in an iron tank, 10 × 4 × 4 ft. The oil collects on the surface, while the water escapes underneath into an adjacent tank of the same size. An oily scum is retained in this second tank also. The water then flows to two larger settling ponds adjacent to each other, one 42 × 42 ft., and the other 57 × 27 ft. These two ponds are also connected to each other by a bend under the water surface. Any oil retained on the surface is skimmed off. After leaving the last settling pond, the effluent undergoes filtration through ashes.

The only chemical work in the county is that owned by Messrs. J. & J. White. These very extensive works are situated on the banks of the River Clyde, in the Parish of Rutherglen, and are included in the area of the Glasgow South-side sewage scheme.

Whisky Distilleries and Breweries.

There are two distilleries in the county, one of long standing at Wishaw, known as the Clydesdale, and one near Garnkirk Station, in Cadder Parish, erected about the year 1899. The Provanmill Distillery, formerly within the county, but in 1899 included in an area annexed to the City of Glasgow, was inspected in 1898 with regard to the disposal of the distillery refuse. At that time the refuse was stored up during the week, and discharged into the Molendinar Burn on Sunday. This arrangement obviated complaint, although a bleach and finishing work situated lower down was dependent upon the Molendinar Burn for a water supply. The Clydesdale Distillery drains into the Burgh of Wishaw sewerage system, and has given no occasion for inspection.

The new distillery erected near Garnkirk, being without any convenient means of disposing of liquid refuse, the owners negotiated with the Lower Ward District Committee as to a drainage outfall, and from a report, of date 15th February, 1899, submitted to that committee by the County Medical Officer, the following information has been extracted :—

The proposal to include the new works of the Northern Distillery Company at Garnkirk within a special drainage district for South Cadder raises the question whether the trade refuse from said distillery might not create difficulties in connection with purification works, if these were constructed on bacteriological principles.

It is well known that the refuse from distilleries has given rise in some cases to serious complaint in connection with the pollution of streams. The distilleries within the county have been visited, and the following information obtained as to the character and source of the drainage from distilleries :—

Malting.—Water used for soaking grain in steep tanks. This water, known as "barley steeps," is not seriously polluted in the process for which it is used. In the distilleries visited it forms part of the trade refuse.

Mashing.—Water used in the refrigerators for cooling the liquor from the mash tuns, known as "worts." This is not polluted in any way, and is sometimes used for other trade purposes, but in the distilleries visited is generally discharged into the drains.

Fermentation.—Water used in cleaning out the fermenting vats after the fermented liquor, known as "wash," is run off. This water is always discharged into the drains, but is not seriously polluted.

Distillation.—(*a*) The liquid refuse from the stills, after distillation is completed, is known as "pot ale," and forms the chief polluting liquid from distilleries. It is sometimes used as a feeding stuff for pigs. In the works visited it is discharged into the drains. (*b*) The water used in the condensing vats during the process of distillation is not polluted in any way. At the works visited it is further utilised in driving a water wheel, and is then discharged either into the drains or an adjacent stream.

General Cleansing.—Washings from casks, floors, and drainage from ground surface go into the drains.

Roof Water.—This is usually discharged into the drains.

Sewage.—At the works visited there were no water-closets.

It will thus be seen that the average composition of distillery refuse will vary according to the method of disposal of the various liquids above named. The quantity of "pot ale," the chief polluting liquid, will vary according to the number of stills and the frequency of operations. At Provanmill, where there is one still of 6,000 gallons capacity for distilling the fermented liquor, or "wash," no distillation is carried on, as a rule, during the months of July, August, and September. During the other months of the year distillation is carried on continuously during five days of the week, there being one discharge every eight hours. The still is charged, on an average, with over 4,000 gallons of the liquor, which, after distillation, leaves at least 3,000 gallons as "pot ale," so that about 45,000 gallons of this refuse has to be disposed of every week. It is stated that "wash" yields about one-tenth of its volume as spirit.

"Pot ale," when examined fresh, is of a brownish colour, and on standing quickly separates into a fine deposit and a somewhat thick

supernatant liquid. The deposit forms about one-ninth of the total volume of the refuse. The results of the chemical analyses are as follows:—

TABLE F.—RESULTS OF CHEMICAL ANALYSES OF POT ALE OR SPENT WASH FROM MALT DISTILLERIES.*

RESULTS STATED AS PARTS PER 100,000.

	Pot Ale—Fresh.		Pot Ale—After 35 days' exposure.	For comparison.
	Clydesdale.	Provanmill.	Clydesdale.	Analysis of Sewage.
Solids—Total, - - -	3794	1854	—	94
Residue after Combustion,	464	219	—	—
Oxidisable Matters, - -	3330	1635	—	—
Solids in Solution, - - -	3238	1700	2428	50
Solids in Suspension, - -	556	154	—	44
Free Ammonia, - - -	0·2	0·188	1·4	4·3
Albuminoid Ammonia, - -	100·3	97·8	43·0	1·8
Oxygen required to oxidise Organic Matter, -	182	175	170	4·1
Acidity = Sulphuric Acid =	0·68 %	0·71 %	0·35 %	Alkaline.

In the above table, the term "solids in suspension" refers to the solids which separated from the "pot ale" after standing for 24 hours, and represents the solids which may be separated by sedimentation. The "solids in solution" are the solids in the supernatant liquid after "pot ale" has stood for 24 hours. The acidity is due to organic acids, but is, for convenience, expressed in terms of sulphuric acid.

Utilisation of "Pot Ale."—The results of chemical analysis show that "pot ale" contains a large amount of solids, mostly in solution. The dissolved solids are evidently of a stable character, and do not rapidly undergo decomposition. From the amount of albuminoid ammonia obtained, these solids are very rich in nitrogenous substances, and, having regard to their origin, show that "pot ale" might form a suitable food stuff for some animals. Indeed, "pot ale" has been and still is used for feeding pigs, and it seems strange that distillers should seek to run "pot ale" into common sewers, considering the wonderful advances that have been made during recent years in the utilisation of waste products. Should farmers or pig-keepers in the vicinity of the distillery be unwilling to take the "pot ale" for feeding animals, then the distillery company might erect and maintain piggeries for the purpose of using up the "pot ale." For the erection of such structures, I understand, there is plenty of cheap land available, and there is reason to believe that such a business might be worked with a profit. These observations are made for the distillery company's serious consideration. And now we have to look at the question of distillery drainage disposal from the local authority's point of view.

* See also papers read at the Aberdeen Congress of the Royal Institute of Public Health, August, 1900.

Purification of Distillery Refuse.—Of the samples obtained from the two different distilleries, that taken from the Clydesdale Distillery may be characterised as a much stronger liquid, the proportion of solids being almost double the amount in the Provanmill sample (see Table). This is probably explained by the fact that the samples were drawn direct from the discharge pipe of the still to avoid contamination, and do not represent an average. This, however, may be obtained by taking the mean of the two. "Pot ale" contains, at least, 2·824 per cent. of solid substances, of which only 0·355 per cent. are removable by settling. On allowing a sample to stand for about 24 hours, the sediment formed by the suspended solids occupies about one-ninth the total volume of the liquid when looked at in a glass vessel. These results, compared with ordinary domestic sewage, show that "pot ale" contains a much larger quantity of solid substances. Thus, the amount of total solids is thirty times greater, and the amount of dissolved solids is nearly fifty times greater in "pot ale" than in sewage.

Whatever means of purification may be adopted, it is quite evident that a much greater expenditure will be incurred in dealing with "pot ale" than with sewage. The purification of "pot ale," along with domestic sewage, presents many points for consideration. The "pot ale," as drawn from the stills, will be of such a high temperature as to render it inadmissible to a public sewer without being cooled. This necessitates the construction of tanks by the distillery company. In allowing this liquid to cool, the suspended solids will fall out. The tank should therefore be so constructed that the liquor would be both cooled and deprived of the suspended solids at the same time. From the experience of other local authorities, it would seem that such tanks are liable to become offensive. They should, therefore, be constructed of an impervious material with a smooth surface, and so as to admit of thorough and frequent cleansing.

The "pot ale" having been cooled and deprived of its suspended matter, we obtain a strong liquor, which differs from sewage in the following respects:—Sewage is generally alkaline or neutral in reaction. It is composed of unstable substances which readily disintegrate, and it abounds with germs which facilitate the disintegration and ultimate purification of the sewage. "Pot ale," on the other hand, has a strongly acid reaction when discharged, due to the presence of organic acids. It not only contains a much larger quantity of solid substances in solution, but these substances are of a highly stable character, and do not readily disintegrate. "Pot ale" is a sterile liquid—that is, it does not contain germs.

Can such a liquid be purified by the action of germs? It is a well-known fact that some species of germs grow luxuriantly in acid media, and "pot ale" is exceedingly rich in substances which support germ life. On general principles, therefore, there can be no doubt as to the possibility of purifying "pot ale" in this way. If a sample of "pot ale" be stoppered when drawn from the still it remains sterile so long as not exposed to the atmosphere. If a small quantity be placed in a vessel and exposed to the atmosphere, the surface quickly becomes covered with a germ growth, which increases in thickness, and after a time particles become detached from the under surface and fall to the bottom. Such a sample examined at the end of five weeks was found to have undergone a very considerable amount of purification, and the result of analysis is given in Column 3 of the Table, and can be compared with the original sample given in Column 1 of said Table. It will be observed that there is

a marked reduction in the albuminoid ammonia, and an increase in the free ammonia, which indicates that a considerable portion of the organic substances in solution have become decomposed. If such an experiment were conducted in a proper receptacle, favourable to fermentive changes, this purification would no doubt go on much more rapidly, but it is only reasonable to suppose that the time required for the purification of "pot ale," through biological means, would be very much longer than that required for the purification of sewage, and probably the length of time required would be in direct relation to the proportion of solids in solution. Since "pot ale," like sewage, can be treated on biological principles, it is only reasonable to suppose that a mixture of the two could also be dealt with. A sample of such a mixed liquid—half "pot ale" and half sewage— has been exposed to the atmosphere, and found to undergo fermentive changes which tend to purify the mixture, but the process was slow.

If the supernatant liquid from the "pot ale" discharges were to be admitted to the public sewers for purification with the sewage, it would be necessary, for the success of the purification scheme, that the local authority should have some undertaking from the distillery company requiring them to provide tanks in addition to those already mentioned for cooling and sedimentation—indeed, an undertaking to carry out such preliminary purification at their works as the local authority might deem necessary. For example, it might be found desirable to have the "pot ale," before admission to the sewer, rendered alkaline by treatment with lime. It might also be necessary to have the discharges of "pot ale" so regulated that the volume would at all times maintain, as far as possible, a definite relation to the volume of sewage by regulating the flow at the works.

With regard to the experience of local authorities in other parts of the country, I have ascertained from county medical officers throughout Scotland that in many instances the distilleries are so situated as not to require purification works. Of those counties where distilleries have provided purification works I might mention Kincardine, Stirling, and Dumbarton, where a large portion of "pot ale" is used for feeding animals, and what cannot be disposed of in this way is either purified by irrigation on adjacent land or by the addition of chemicals.

To sum up, we may conclude (1) that it is very desirable that no "pot ale" should be discharged into the public sewers. If this be excluded from the distillery drainage there can be no objection to the inclusion of the distillery within a special drainage district. (2) If "pot ale" is to be discharged into the sewers, the distillery company should come under some obligation with regard to the carrying out of a preliminary treatment of the "pot ale" at their works, and contribute financially both to the cost of the original sewage works and to the annual cost of sewage purification.

Until more definite information is obtained as to the quantity and composition of drainage from the new distillery, the nature of the preliminary treatment need not be further discussed.

The formation of a special drainage district to include the new distillery was delayed, and an arrangement made whereby a connection with an existing drainage district was obtained. The terms of the arrangement included the provision at the distillery of proper means for the interception of solid matter in suspension. Several inspections were made after the distillery was in operation during the autumn of 1900, and intermittent pollutions were then detected and reported upon.

It was found that the "pot ale" was first collected in circular tanks or vats, each with a capacity of 80,000 gallons. In each vat there were two 6-inch draw-off pipes; one at the bottom, and the other about 6 feet from the bottom. The lower pipe was connected with a steam pump, and by this means the sludge or sediment was drawn off and raised to an elevated tank, from which it was discharged into bags, or otherwise disposed of. By means of the upper pipe the liquid found its way by gravitation to a sewage tank. This sewage tank also received drainage from the offices and works. By means of a pump the contents were elevated to a high-level tank, from which by gravitation they entered the sewer. Any overflow from the "pot ale" tanks and sewage tanks was liable to find its way into a ditch which discharges into another ditch on Cardowan Estate, thence to the Bathlin Burn. On several occasions pollutions were complained of as affecting the latter ditch and burn. An inspection showed evidence of pollution of an offensive character for a considerable distance below the distillery. This pollution seemed to be due to carelessness on the part of the employees in charge of the pumping and other arrangements above-mentioned. With a view to preventing the escape of polluting liquid the distillery company formed a dam across the ditch on their grounds, and provided a pump to raise the escaping liquid back to the sewage tank. The dam proved insufficient, and ultimately a pond, constructed of puddled clay, was provided. This was towards the end of September, 1900, and the company shortly thereafter went into liquidation.

The Wellshot Brewery, situated at Eastfield, in the parish of Rutherglen, is the only one in the county, and is not a source of pollution.

III.—SEWAGE POLLUTIONS.

The term sewage does not imply that the pollutions under this heading do not contain trade refuse, but that their prevailing character is that of domestic or household liquid refuse. The most serious of these pollutions arise in connection with towns and populous places for which local authorities are responsible. As the administration of the Rivers Pollution Prevention Act was, until 1889, entrusted solely to these same authorities, it is easy to understand how so little action was taken and little or no effort made to prevent or mitigate pollutions.

In order to show at a glance the position and extent of the various sources of sewage pollution, a map (No. II.) and the following table have been prepared :—

TABLE G.—BURGHS AND OTHER POPULOUS PLACES WITH SEWERAGE SYSTEMS UNDER THE CONTROL OF THE LOCAL AUTHORITY.

CITY AND BURGHAL AREAS.—*Population—Census, 1901.*

Glasgow, ...	761,709	Coatbridge, ...	36,991	Wishaw, ...	20,873
Govan, ...	82,174	Hamilton, ...	32,775	Rutherglen, ...	17,220
Partick, ...	54,298	Motherwell, ...	30,418	Lanark, ...	6,567
Kinning Park, ...	13,852	Airdrie, ...	22,288	Biggar, ...	1,366

Towns and Villages under County Administration.	Estimated Population.*	Towns and Villages under County Administration.	Estimated Population.*
Upper Ward.		*Middle Ward (continued).*	
Carluke, ...	5,255	East Kilbride, ...	2,050
Carnwath, ...	900	Holytown, ...	1,825
Crosslaw, ...	395	Larkhall, ...	11,000
Douglas, ...	1,555	Mount Vernon, ...	4,015
Law, ...	1,660	Netherton, ...	620
Lesmahagow, ...	2,105	New Stevenston, ...	3,255
Middle Ward.		Newton and Flemington,	4,840
Aitkenhead and Tannochside, ...	3,225	Stonehouse, ...	3,260
Baillieston, ...	3,585	Strathaven, ...	5,020
Bellshill, ...	9,890	Uddingston, ...	7,270
Blantyre, ...	12,755	*Lower Ward.*	
Bothwell, ...	2,860	Carmunnock, ...	545
Busby, ...	580	Govan, ...	1,500†
Cambuslang, ...	13,450	Rutherglen, ...	3,850‡
Chapelhall, ...	1,905	Shettleston and Tollcross,	20,590
Cleland and Omoa, ...	2,055	South Lenzie, ...	1,165

* Estimated population of Special Drainage District. † Institutions only. ‡ District not yet formed.

EXPLANATORY NOTES RELATIVE TO MAP No. II.

PUBLIC WATER SUPPLIES.—The public water-works and their drainage areas are shaded *blue*. In Table L some particulars as to the various water-works and the local authorities owning them are given.

TRADE WATER SUPPLIES.—Pumping stations erected for the supply of public works and for other trade purposes are indicated by numbers, coloured *red*, and placed near the position of the pumping stations on the streams A list of the works thus supplied, and a note of their daily consumpt, &c., are given in Table K.

RAINFALL STATIONS.—The position of these are indicated by numbers coloured *black*. Statistics as to rainfall are summarised in Table M.

SEWAGE POLLUTIONS arise in connection with towns or populous places. These have been indicated on the map thus:—The actual areas of the City of Glasgow and adjacent burghs are roughly outlined and shaded *black*. The other burghs are indicated by circles faintly shaded in *black*, the size of the circle roughly corresponding with the population. All the other populous places formed into special drainage districts are indicated by circles shaded *pink*, and here also the size of the circle corresponds with the population, as follows:—Localities having populations of less than 1,000 are shown by a dot; populations between 1,000 and 5,000 are indicated by circles $\frac{1}{16}$ of an inch in diameter; between 5,000 and 10,000 by circles $\frac{2}{16}$ of an inch in diameter; and so on, the size of the circle increasing proportionately with the population. (See Table G.)

MAP No. I. was issued with the Annual Report for 1900, and is only issued with a limited number of copies of this Report at page 45. It shows the position of the industrial sources of pollution—coal-dross washers, iron works' sulphate of ammonia plant, manufactories, &c.—at that date.

MAP Nº II— See explanatory notes and relative Tables

THE CLYDE IN THE COUNTY OF LANARK — WATER SUPPLIES, TOWNS & VILLAGES &c.

SCALE

In considering the sources of sewage pollution, it will be unnecessary to refer to the City of Glasgow and adjacent burghs, which drain to the lower reaches of the Clyde. In considering all other sources, it will be remembered that the responsibility for sewage pollutions rests in burghs with the burgh commissioners or town council, and in county areas—where special drainage districts have been formed—with the district committees as local authorities under the Public Health Act.

SOURCES OF SEWAGE POLLUTION.

Burghs.

Airdrie (Population, 22,288).—The Burgh of Airdrie drains to the North Burn and the South Burn, which flow in the direction of Coatbridge. No sewage purification works have yet been provided, but joint-action with the Burgh of Coatbridge has been under consideration.

Coatbridge (Population, 36,991).—The Burgh of Coatbridge has numerous drainage outfalls into the following streams, viz.:—The North Burn, Gartsherrie Burn, and Luggie Burn, which also receives the South Burn aforementioned. The combined pollutions from the Burghs of Airdrie and Coatbridge is so serious that it is not only traceable in the Luggie Burn to its junction with the North Calder, but its effect upon the North Calder is so marked that it completely alters the character of this stream during the rest of its course to the River Clyde. No purification works have yet been provided, but joint-action with the Burgh of Airdrie has been under consideration.

Hamilton (Population, 32,775).—The Burgh of Hamilton drains direct to the River Clyde by two main outfalls. The upper outfall is the Cadzow Burn, and the lower outfall a recently-constructed sewer discharging at the Park Burn below Bothwell Bridge. The effect of these sewage outfalls upon the Clyde can be traced for a considerable distance down the river. No purification works have yet been provided, but reports have been obtained from a civil engineer and a mining engineer showing the difficulties liable to be encountered in providing such works.

Lanark (Population, 6,567).—There are two drainage outfalls from the Burgh of Lanark direct to the River Clyde. The upper outfall flows through the lands of Castlebank in an open channel,

and is there apt to create a nuisance. The lower outfall is situated above Kirkfieldbank Bridge, where the effect upon the Clyde is distinctly seen. No sewage purification works have yet been provided, but the matter is receiving serious consideration.

Motherwell (Population, 30,418).—This burgh has already been referred to at page 21 in connection with "Court proceedings." In the scheme proposed by Mr. Carter, C.E., there will be provided three separate sewage purification works—two situated on the South Calder, and one on the River Clyde. At each, tanks and filters are the means of purification proposed to be adopted.

Rutherglen (Population, 17,220).—This ancient Burgh is included in the area of the Glasgow South-side sewage scheme.

Wishaw (Population, 20,873).—The sewage of the Burgh has, since about 1860, been irrigated on the farm lands of Carbarns. From notes of an inspection made some time ago, the following description is taken:—The irrigation is carried on chiefly on the farm of Lower Carbarns, which is leased by the Commissioners from Lord Belhaven until Martinmas, 1913. A large field adjoining, on the estate of General Lockhart, is also used for irrigation. The area covered by these lands extends to about 160 acres. As the population of the Burgh of Wishaw was 20,873 in 1901, there will be about 8 acres of land for sewage disposal for every 1,000 of the population. The surface of the ground slopes towards the River Clyde, and at some parts the declivity is considerable. In these higher parts it is almost impossible to carry out broad irrigation and intermittent downward filtration. At present the sewage is simply led in open channels along the face of the hill. Part of the area is under pasture, part under crop cultivation, and part is utilised for fruit growing. The soil is loamy, and not unsuitable for sewage irrigation.

The disposal of the sewage is under the charge of a man employed by the Commissioners, who seems to exercise full control in the allocation of the sewage, and the results obtained, considering the method employed, are not wholly unsatisfactory. Samples of the sewage as it enters the lands, and samples of the effluent as it discharges into the River Clyde, were obtained, and the results of analyses are given in the subjoined Table H. These show that the amount of oxidisable substances in the sewage is greatly reduced. No doubt the configuration of the upper parts of this land prevents full advantage being taken of it for irrigation

purposes, and there is a large quantity of pit water presently being allowed to mix with the sewage, which, by mere dilution, tends to improve the effluent.

TABLE H.—WISHAW SEWAGE IRRIGATION.

CHEMICAL ANALYSES—RESULTS STATED AS PARTS PER 100,000.	1899.				1902.	
	7th MARCH.		10th MARCH.		7th NOVEMBER.	
	Sewage.	Effluent.	Sewage.	Effluent.	Sewage.	Effluent.
Chlorides as Cl, ...	6·5	4·3	5·5	5·1	5·0	4·5
Nitrites and Nitrates as NO_3, ...	0·0	0·0	0·0	0·0	—	—
Free or Saline Ammonia, ...	4·3	1·9	3·6	2·6	1·63	1·58
Albuminoid Ammonia, ...	1·8	1·4	1·7	1·4	—	—
Oxygen absorbed in 4 hours at 80° F., ...	4·1	0·7	3·9	0·8	1·67	1·31
Solids, total, ...	94·0	68·5	108·5	91·4	—	—

Biggar (Population, 1,366).—There are two sewer outfalls carrying off the sewage not only from all houses within the burgh, but also, by arrangement, from several houses immediately outside the burgh, so that the population draining into the sewers will probably be about 1,500. Both these outfalls are connected with sewage purification works which drain into Biggar Water, thence to the Tweed. The west end outfall conveys about two-thirds of the sewage, and the east end outfall about one-third. Formerly the west end outfall was led across Biggar Water, and, by arrangement with the tenant of Boghall Farm, the sewage was irrigated on these lands before entering the stream, but owing to a change of tenancy this arrangement was departed from, and for some time the sewage entered Biggar Water direct.

Early in the year 1900 the Commissioners acquired an area of nearly 8½ acres of land extending along the north side of Biggar Water a distance of about 400 yards or thereby. These meadow lands are suitably situated, and well adapted for irrigation purposes. The western outfall was then intercepted and carried to these lands, where two settling tanks, each measuring 21×9×4 ft., and having a total capacity of about 9,450 gallons, were constructed, with a scum board at the outlet. The sewage discharged into these tanks was freed from gross solids, which

prevented the carriers dug out of the soil becoming clogged, and facilitated purification. As the extent of the irrigation area is large in relation to the population, it is not only sufficient to purify the the sewage, but allows of crops being raised in the most profitable manner.

The sewage of the east end outfall receives on its way a considerable quantity of surface drainage, and is first irrigated upon 6 acres of meadow land cropped and managed by the superior. The commissioners subsequently acquired 2½ acres of land adjoining this area. The whole of these lands is presently in grass, and the meadow-hay crop is of considerable value. The irrigation is so arranged that the sewage can be diverted from one portion to another when the hay crop is being reaped. It is very interesting to watch the gradual purification of the sewage on these irrigation fields. Along the main sewage carriers there is abundant evidence of bacterial growth, the bottom and sides of the channels being covered with flocculent masses of germs. The gradual change in the sewage from a greyish, turbid, foul liquid to a clear effluent can be easily traced.

The results of analyses of samples taken have been found satisfactory as is shown by the following table:—

TABLE J.—BIGGAR SEWAGE IRRIGATION.

CHEMICAL ANALYSES—RESULTS STATED AS PARTS PER 100,000.	16TH FEBRUARY, 1900.	
	Sewage.	Effluent.
Chlorides as Cl., ...	3·1	2·3
Nitrates as NO_3, ...	·225	1·485
Nitrates as NO_2, ...	Abundant.	Present.
Free or Saline Ammonia, ...	1·01	·091
Albuminoid Ammonia, ...	·324	038
Oxygen absorbed in 4 hours at 80° Fahr.,	2·72	·45
Solids dissolved, ...	23·0	15·0
,, suspended, ...	43·0	—
,, total, ...	66·0	15·

Special Drainage Districts in the Upper Ward.

Carluke (Population, 5,255).—About three-fourths of the sewage from this district is disposed of by irrigation on suitable land. There are two outfalls, but by far the greater portion of the sewage discharges at the southern outfall, where it is irrigated. For this purpose two fields, one of 14 acres and the other of 7 acres, are leased by the committee of management. These fields are sub-let for grazing purposes, and the debit balance between revenue and expenditure averages about £10 annually. The effluent discharges into Jock's Burn.

The north-east outfall also discharges into Jock's Burn, but without purification, although efforts have been made to acquire land for irrigation purposes.

Carnwath (Population, 900).—This district was only recently formed, and the sewerage works have not yet been carried out. Provision, however, has been made for the construction of a tank and filters, and the effluent will discharge into Carnwath Burn, which joins the Clyde.

Crosslaw (Population, 395).—The sewage from this district is irrigated on farm lands by an arrangement with two different farmers; one of these takes about one-third, and the other about two-thirds of the sewage of the district. The effluent discharges into a small stream, which after a short run joins the Clyde.

Douglas (Population, 1,555).—There is one main outfall from this district, and the sewage, before entering the Douglas Water, passes through an intercepting cesspool tank, which is cleaned out annually. The deposit amounts to about six cart loads. There is also a small sewer, draining the houses of not more than 300 of the population. This sewer discharges into the Springfield Burn, which is now enclosed in a pipe.

Law (Population, 1,660).—There are several drainage outfalls from this district, and one of these discharges on to farm lands. Most of the sewage enters the Gill Burn.

Lesmahagow (Population, 2,105).—The sewage from this special district discharges into the river Nethan by three different outfalls. The quantity of sewage, however, is small, and the water of the stream shows little evidence of pollution. Th committee of

management had the matter under consideration, and have in view the acquiring of a piece of land for the purpose of erecting purification works.

SPECIAL DRAINAGE DISTRICTS IN THE MIDDLE WARD.

Aitkenhead and Tannochside (Population, 3,225).—This district comprises mostly miners' dwellings. It was recently formed (January, 1898), and has but one sewage outfall, which meantime is connected to a sewer which passes through the proposed site of purification works for the north-west portion of the Uddingston Special Drainage District. The sewage, however, presently discharges into the River Clyde near Haughhead Bridge.

Baillieston (Population, 3,585).—There are two outfalls from this district, both to the North Calder. The western outfall first discharges into a nameless streamlet, which in summer time is almost dry. The purification effected in its course of about three-quarters of a mile to the North Calder is very considerable, but it is liable to give off offensive odours, and occasions complaint. The eastern outfall sewer carries only a small quantity of sewage. (See analyses of samples taken on 6th October, 1902, in Appendix —Table Y.)

Bellshill (Population, 9,890).—The town which gives its name to this district is situated on a ridge draining, on the north side, to the Shirrel Burn and North Calder Water, and, on the south side, to the South Calder Water. In connection with the prevention of pollution, the committee have under consideration the necessity of extending the district and providing sewage purification works.

Blantyre (Population, 12,755).—This district was enlarged in the year 1898, and again in 1900, when the committee acquired at the old Blantyre Mills a site for purification works. An intercepting sewer has been laid to the site, but at present the sewage discharges into the River Clyde. The proposed purification works comprise tanks and filters.

Bothwell (Population, 2,860).—Two of the sewer outfalls from this district discharge into the Pow Burn, thence to the Clyde. One of these outfalls has been connected with the Uddingston Sewage Purification Works, and for the interception of the other outfall sewage purification works are presently to be constructed. These consist of a covered tank of 31,000 gallons capacity, and two continuous filters, each 75 square yards in area, and 3 feet deep. There are three other outfalls which discharge directly into the River Clyde, but the quantity of sewage from these is not great.

Busby (Population, 580).—This district was only formed in October, 1899, and sewage purification works have been provided. These comprise a covered tank of 30,000 gallons capacity, and four single-contact filters, each 80 square yards in area, and 3 feet 6 inches deep. The outfall from the works is into the White Cart.

Cambuslang (Population, 13,450).—There are three outfalls from this district direct to the River Clyde. Two years ago negotiations were entered into with the authorities of the Lower Ward, Rutherglen, and Glasgow, regarding the laying of a joint-outfall sewer and the reception of the sewage from the district into the sewers of the Glasgow South-side scheme. The committee have also under consideration an alternative scheme in the provision of sewage purification works near to the district.

Chapelhall (Population, 1,905).—There are two outfalls from this district, one to the Shotts Burn and one to the North Calder. Pollutions were complained of in connection with these outfalls by the tenants of the farm lands through which the stream flows. The committee, to obviate these complaints, provided a gravitation supply of water for the fields affected.

Cleland and Omoa (Population, 2,055).—This district was only formed in October, 1900, and sewage purification works, consisting of a tank of 30,000 gallons capacity and 5 single-contact filters, each 51 square yards in area and 3 feet 6 inches deep, have been provided. The outfall is to the Tillon Burn.

East Kilbride (Population, 2,050).—This district was formed in June, 1899, and, as planned, is provided with sewage purification works, consisting of tanks and filters. The filters, however, have not yet been erected, owing to the cost of the works having almost exceeded the rate of assessment allowed by statute—the drainage rate for 1902-03 was 1s. 3½d. per £. The effluent discharges into Kittoch Water.

Holytown (Population, 1,825).—The sewage from this district enters the Shirrel or Legbrannock Burn direct, but the sewers have been constructed with a view to a scheme of sewage purification being carried out.

Larkhall (Population, 11,000).—There are three outfalls from this district—two to the River Avon and one to the Clyde. The sewage discharging to the Avon is treated on two plots of ground

leased by the committee—one extending to about ten acres, and the other to about three and a-quarter acres. The system employed is broad irrigation, the sewage being applied to different portions of the meadows in succession; no portion receiving sewage for more than two days in succession. The drainage to the Clyde is also irrigated on about four acres of farm lands by an arrangement with the tenant farmer. The cost of the purification of the sewage is about £114 annually.

Mount Vernon (Population, 4,015).—This is a scattered district, including the village of Carmyle and a small portion of Tollcross. The drainage is mostly direct to the River Clyde, but a small portion first discharges into the Battles Burn at Tollcross. Sewage purification works have not yet been provided.

Netherton (Population, 620).—A number of large public works are included in this district, which was formed as recently as 1901. Sewage purification works, consisting of a tank and land for irrigation have been provided. The effluent will discharge into the River Clyde.

New Stevenston (Population, 3,255).—This district is adjacent to Holytown. The drainage is direct to the Shirrel or Legbrannock Burn, and the sewage will be purified along with that from Holytown.

Newton and Flemington (Population, 4,840).—This district was only formed in 1901, and sewerage and sewage purification works have not yet been carried out, but are designed and expected to be commenced shortly. The proposed works are situated on the Light Burn, and the effluent will discharge into the River Clyde.

Stonehouse (Population, 3,260).—Sewerage works have been carried out, and the committee have also given the question of sewage purification careful consideration, but difficulties have occurred in the way of acquiring land for the purpose. The main outfall is to Cander Water, which joins the Avon.

Strathaven (Population, 5,020).—Sewerage and sewage purification works have recently been constructed in this district. The purification works consist of two covered tanks of a total capacity of 105,600 gallons, and 10 contact filters in two sets of 5 each; each filter being 140 square yards in area and 3 feet 6 inches deep.

Sewage Purification Works in the Middle Ward District of the County.

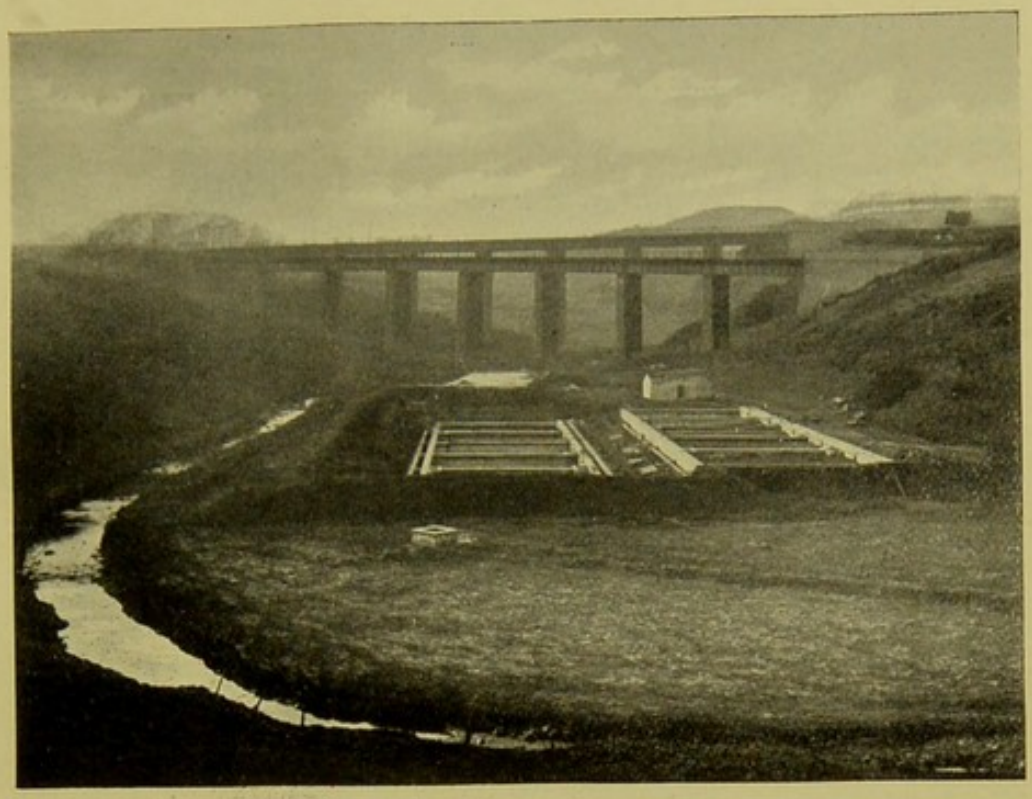


Photo. showing Strathaven sewage purification works, situated on the Powmillon Burn.

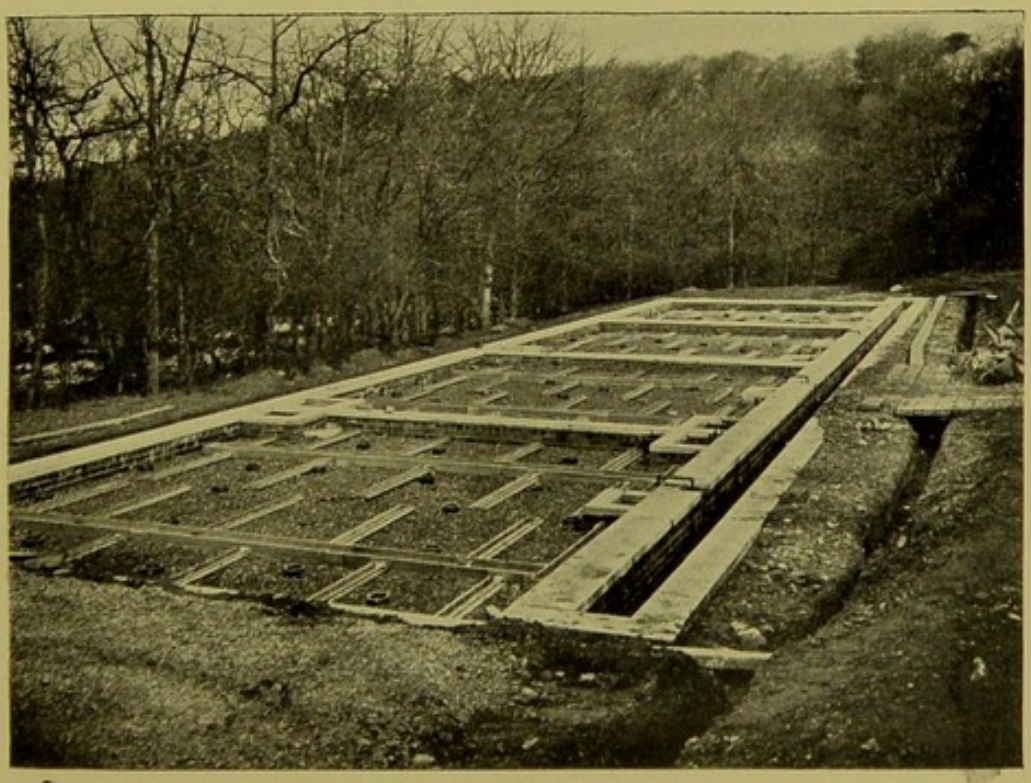


Photo. showing the filters at Busby sewage purification works.

Sewage Purification Works.—Cleland and Omoa.

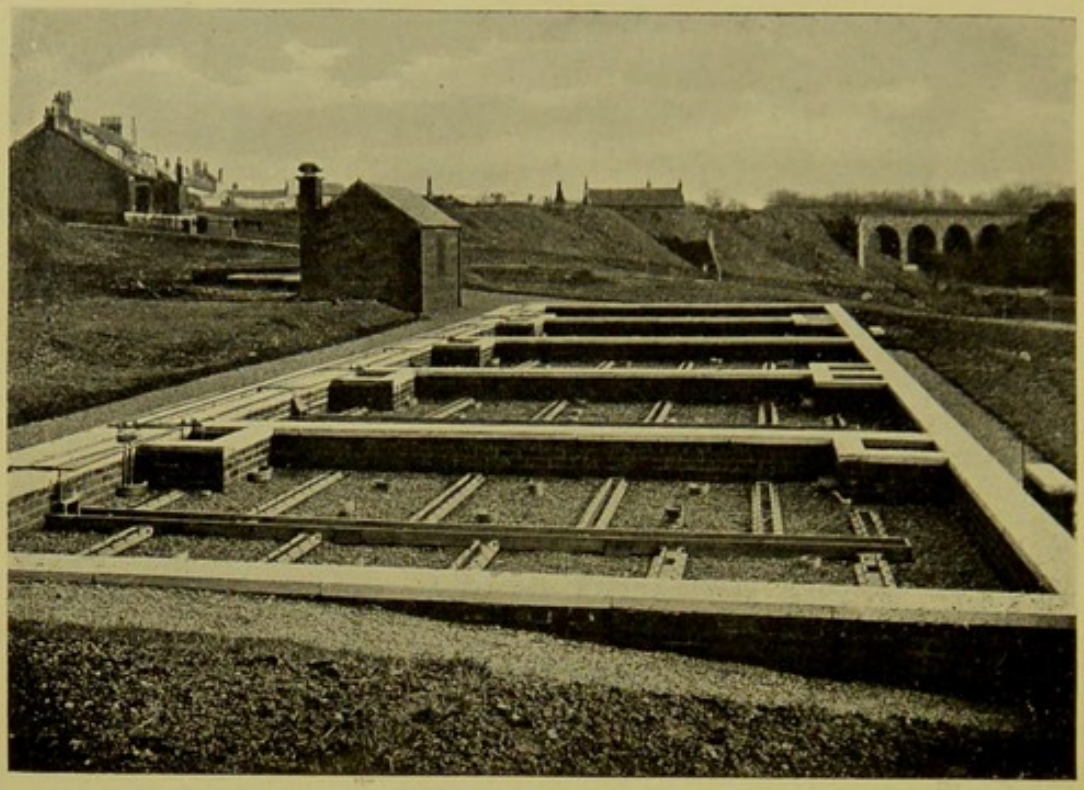


Photo. showing the Filters.

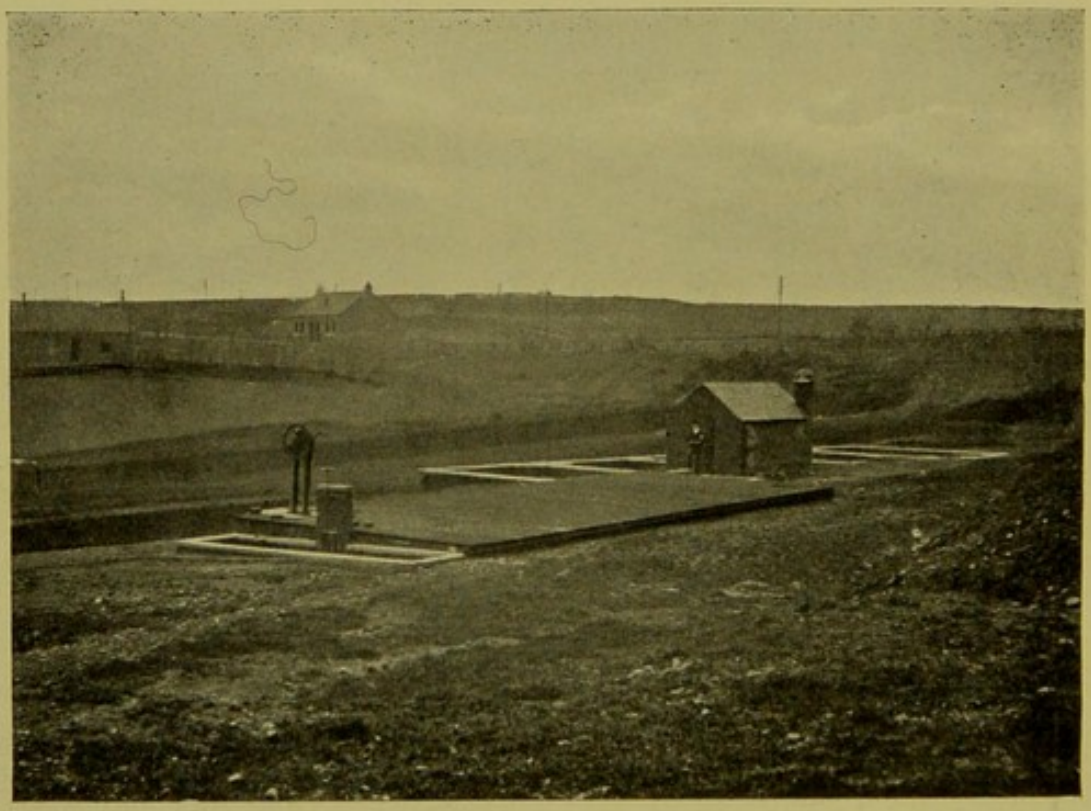


Photo. showing the Covered Tank, &c.

The installation has been so designed that the sewage can be treated either by double contact over a series of 5 filters or by single contact over the series of 10 filters. The effluent discharges into the Powmillon Burn. The drainage rate of assessment, for 1902-03, in this district was 1s. per £.

Uddingston (Population, 7,270).—The outfall to the Pow Burn from this district has been provided with sewage purification works. These works, being the first of their kind in the county, were the subject of a special report which will be found at the end of this portion of the report (pp. 89-126). There are also other two outfalls direct to the River Clyde.

Special Drainage Districts in the Lower Ward.

Carmunnock (Population, 545).—The sewage from this small district enters the Padmure Burn without purification. This burn joins the Kittoch Water which flows into the White Cart.

Govan District (Population, 1,500) only includes Govan Combination Poorhouse and Hospital and Shieldhall Fever Hospital. The sewer outfall to the Clyde will be connected up with the Glasgow South-side scheme.

Rutherglen (Population, 3,850).—This district has not yet been formed, but provision has been made in the Glasgow Sewage Act of 1898 whereby, when the district is formed, all the sewage will, along with the sewage of the Burgh of Rutherglen, join the sewers of the Glasgow South-side scheme.

Shettleston and Tollcross (Population, 20,590).—This district is contiguous to the eastern boundary of the City of Glasgow, and has several outfalls—one on the north, connected to a Glasgow sewer on the Cumbernauld Road; and one at Carntyne, both draining into Dalmarnock Sewage Works; one, known as the Tollcross Burn sewer, entering the Clyde; and one draining to the Battles Burn (which ultimately joins the River Clyde) at Tollcross.

South Lenzie (Population, 1,165).—The sewers from this district have an outfall to irrigation lands near Kirkintilloch.

Mention might also be made of several village communities and public institutions provided with sewage purification works.

Village Communities.—The village of *New Lanark*, so well known about the beginning of last century as the community where Robert Owen's ideas of social reform were first carried out, has a population of about 800, and is situated close to the banks of the Clyde. The present proprietors carried out considerable improvements in the houses about two years ago, and, in providing a proper system of drainage, constructed sewage purification works consisting of a tank and filters.

Muirpark Rows are modern miners' dwellings situated near Bellshill, and have a population of about 650. In connection with these houses are trough water-closets. The drainage from these, with the drainage from the houses, passes through lands on Douglas Support Estate into the North Calder. For the prevention of pollution, sewage purification works were constructed, consisting of tanks and filters, with an arrangement for the continuous addition of chemical precipitants—sulphate of alumina and lime.

The miners' houses connected with *Blantyre Ferme Colliery* have a population of about 250, and are situated close to the Rotten Calder—a pure stream. At the suggestion of the Middle Ward District Sanitary Inspector the owners constructed a septic tank and an irrigation channel, which is filled with furnace clinker or engine ashes, and, as the effluent from the tank passes along this channel, surface filtration or irrigation effects considerable purification. A similar system has been adopted at a model lodging-house near Cleland, known as the *Auchinlea Workmen's Home*, which accommodates about 120 persons.

Public Institutions.—*Lanark District Asylum* has a population of about 850, and is situated at Hartwood, in Shotts Parish. The sewage is disposed of by irrigation on lands belonging to the institution, and the effluent drains to a small streamlet which enters South Calder Water. The crude sewage was at first passed through tanks, but these in recent years have not been used.

Gartloch Asylum has a population of about 650, and is situated in the most southern corner of Cadder Parish, near Bishop Loch. As the drainage is towards the loch, the question of sewage purification received serious consideration, and ultimately what is known as the international system was adopted. By this method the sewage is treated with chemical precipitants and filtered. There is also an arrangement, where the soil pipe joins the drain, for intercepting the solids, which are collected in small wire boxes.

These receptacles are removed daily in a hand-barrow, and their contents disposed of—a most objectionable structural arrangement and disgusting practice. The results obtained by this treatment are, however, fairly satisfactory.

County Isolation Hospitals in the Middle Ward District are provided with tanks and filters. The largest of these hospitals is situated near Motherwell, and its maximum population has been about 250. The tanks here are open, but provided with a scum board. The tanks were in use continuously for about three years without requiring to be cleaned out. When this was done, the sludge was allowed to drain and solidify in close proximity to the hospital without giving off any offensive odours. During the renewing of an electrical storage battery, large quantities of sulphuric acid were discharged into the drains, and so affected the tanks that they have not yet recovered their former efficiency. There are also two filters of engine ashes worked intermittently. At a smaller hospital, situated near Stonehouse, a hydraulic pump to raise the sewage on to adjacent farm lands for irrigation has been provided. The drainage was into a small streamlet to which dairy cattle had access, and, owing to complaints by the farmer, irrigation was adopted.

Complaints of Sewage Pollution have arisen mainly in three ways:—

(1) Where streams are used for watering cattle, complaints have been made by many dairy farmers and riparian proprietors. Considerable differences of opinion still seem to exist as to the effect a polluted water supply has upon cattle. At one farm where sewage irrigation is carried on, the tenant stated that the cattle preferred sewage effluent to clean water. In one case, specially brought under my notice, where a small stream received the sewage effluent from a small hospital, the farmer alleged that two of his cattle suffered from symptoms attributable to drinking the polluted water of this stream, although the effect of the pollution at the point accessable to the cattle was not well marked. By an arrangement with the farmer, it was agreed that one of the animals should be slaughtered, and that, if the *post-mortem* examination revealed conditions attributable to sewage pollution, he should receive full compensation for the loss of the animal. The result of the examination, however, showed that its whole abdominal organs were very seriously affected with tuberculosis.

(2) Where manufacturers use river water for industrial purposes, a few complaints have been received, and in one instance the pollution was due to an alleged accidental discharge of paper mill

refuse. The pollution was in this case so serious that the water of the stream could not be pumped to the works affected. Fortunately the pollution soon ceased, otherwise serious loss might have resulted.

(3) Where the pollution of a stream by sewage is so serious as to create a nuisance, complaints have been received from many owners and occupiers of houses situated in close proximity to such streams, but in not a single instance has such a complaint been made with regard to the Clyde itself, except at Bothwell, where certain proprietors complained of sewage pollution from the Burgh of Hamilton. This pollution is very apparent from Bothwell Bridge, and is offensive to the eye, but it is doubtful whether it is so to the sense of smell. (See illustrations.)

It is also satisfactory to note that the Clyde and its tributaries are not used as a source of water supply for domestic purposes at any point where they are liable to pollution.

The **preventive measures** in operation against sewage pollution might be summarised under two headings, viz., (1) broad irrigation, with utilisation, or cultivation of the land, and (2) treatment in septic or settling tanks and filters.

Broad irrigation is systematically carried out in the following localities, which have a total population of about 39,659, viz.:— the Burghs of Wishaw and Biggar, and the special drainage districts of Carluke, Larkhall, and South Lenzie.

Settling tanks and filters are in actual operation in the following localities, with a total population of about 10,000, viz.:— Strathaven, Busby, Cleland and Omoa, and part of Uddingston. Sewage purification works, consisting of tanks and filters, are either partly carried out or have been planned for Blantyre, part of Bothwell, East Kilbride, Newton and Flemington, Netherton, and the Burgh of Motherwell, with a total population of about 52,163.

Some reference might also be made to the works already constructed and being carried out by the Corporation of Glasgow.* The Dalmarnock Sewage Works were opened on 2nd May, 1894. These works deal with the sewage from the eastern portion of the city and a small portion of the Lower Ward district. In these areas are situated a large number of public works producing trade effluents. The sewage is first freed from gross solids, and then treated with chemical precipitants. At first sulphate of alumina and lime were used for this purpose, but more recently, I understand, perchloride of iron has been employed. The sludge is removed to filter presses,

* Glasgow Main Drainage, by Mr. A. B. M'Donald, City Engineer, read before the Institution of Engineers and Shipbuilders in Scotland on 24th April, 1900.

View on the Clyde immediately below Bothwell Bridge, showing the Park Burn Sewer Outfall from the Burgh of Hamilton discharging in mid channel, and traceable down the river for some distance. The analyses of samples taken from the Clyde some distance below the Outfall are given in Table O, No. 18, and Table R, No. 8.

Photo. taken 8th October, 1902, when the flow in the river was very low.

Same view on the river, but outfall under water.
Photo. taken 4th April, 1903, when the flow in the river was little above an average.

where sufficient liquid is expressed to allow of it being handled in the form of a cake, which is mixed with other city refuse and sold as manure.

In 1896 Parliamentary powers were obtained for intercepting the sewers on the north side of the Clyde, and erecting works at Dalmuir for the treatment of the sewage, of which the estimated dry weather flow is 49,000,000 gallons daily. This scheme enables the Corporation to deal with the sewage of Glasgow and Partick, the districts of Temple, Knightswood, Jordanhill, Scotstounhill, and Yoker, the landward part of Renfrewshire, Dumbartonshire south of the canal, the Burgh of Clydebank, Radnor Park, Bearsden, and also, if need be, Duntocher, Faifley, Old Kilpatrick, and Bowling. This drainage area will include rather more than 9,000 acres, or about 14 square miles. These works are being constructed on somewhat similar lines to the works at Dalmarnock, but it is proposed to run the sludge into vessels and have it conveyed down the firth, where it will be deposited in the deeper portions of the channel.

In 1898 Parliamentary powers were obtained for the interception of all the sewage entering the River Clyde on the south side of the river, and for its treatment at Braehead, within the Lower Ward District of the county. The estimated dry weather flow in this case is 45,000,000 gallons daily, so that the total amount of sewage expected to be dealt with daily at the three works is estimated at about 110,000,000 gallons.

The intercepting sewers and works at Dalmuir are being proceeded with, and it is expected that the whole scheme will be completed within five years.

In all these schemes the greater portion of the expense lies in the construction of intercepting sewers, and in conveying the sewage, including pumping, to the various outfalls mentioned.

The amount of purification obtained and anticipated is indicated in the following extract from a paper, dated 31st August, 1901, by Mr. A. B. M'Donald, M.Inst.C.E., City Engineer :—

"The working result of the sewage treatment at Dalmarnock is, that every trace of suspended matter is removed, and that 30 per cent. of purification is attained, calculated on the basis of oxygen absorbed in four hours at 27° centigrade. The result may leave something to be desired, but it must be borne in mind that reason imposes a limit on achievement in this direction. The quantity of sewage disposed of at Dalmarnock is, as we have seen, 16,000,000 gallons, and it is discharged in its altered condition into a tidal stream of vastly superior volume. Measured at a station seven miles higher up the river, far beyond the tidal range, the

down-stream flow is 700,000,000 gallons per day—more than forty times the quantity of sewage at Dalmarnock, where the dilution is further augmented by the tidal water. It has not yet been ascertained what degree of saturation is needed to secure perfectly innocuous conditions, but it may be safely asserted that there is here a near approach to the complete elimination of every element of objection. Further down the river, at Braehead and at Dalmuir, the 94,000,000 gallons of purified sewage will come in contact with 3,000,000,000 gallons of tidal water, and may with safety be left to natural agencies for their further improvement, the more especially as the quality of sewage dealt with on the lower reaches of the river will be of a simpler character than that presently treated at Dalmarnock, and, consequently, more likely to yield an effluent of a better character."

UDDINGSTON SEWAGE PURIFICATION WORKS.

REPORT SUBMITTED TO THE MEMBERS OF THE MIDDLE WARD DISTRICT COMMITTEE IN DECEMBER, 1901.

The Sewage Purification Works at Uddingston have now been in operation for two years. As they were the first works in this County of any size constructed on the so-called septic tank system, I made a number of inspections and analyses for the purpose of determining the purification effected. It is perhaps desirable that these investigations should be continued, but I beg to submit for your consideration the results already obtained. These results were submitted to the District Engineer from time to time, so that advantage might at once be taken of the information afforded.

It will be remembered that the works were erected to obviate the most serious sewage pollution affecting the little stream known as the Powburn. Looking at the map on the opposite page, that portion of Uddingston draining to the sewage works is shown in pink colour, but there is also a small portion of Bothwell District draining to these works not shown on the plan.

A complete list of all the pollutions affecting the Powburn, and of the means adopted to prevent them, is given in the first part of the report (Part I.).

The second part of the report (Part II.) has been supplied by the District Engineer, and gives a description of the sewage works, with relative plans, which show a large covered tank, five filter beds, and various accessories.

When these reports have been carefully studied, the Committee will realise (1) the purpose for which the works were erected, and (2) how they are constructed and managed.

The question with which I am chiefly concerned, viz., the purification results obtained, is dealt with at considerable length in the third part of the report (Part III.), but I might here briefly discuss some of the more important points.

Sewage.—The volume or quantity and the character or quality of the sewage have been found to vary within very wide limits. The dry weather flow is not excessive, but during wet weather the volume entering the works averages some days 12,000 gallons per hour. This raises a question

as to whether the storm overflows in such districts should be so constructed as to allow a greater volume to escape through them. In this connection reference might be made to "Document No. 5" appended, which gives the provisional conditions laid down by the Local Government Board for England.

In town areas the density of the population is considerably greater than in populous places forming special drainage districts; for example, in the area draining to the Uddingston Works the population is in the proportion of 30 persons per acre, whereas in the City of Glasgow the population is in the proportion of about 60 persons per acre, and the density varies in the different parts of the city from under 40 to 350 persons per acre. It might then be argued that, if the storm overflow permissible in districts densely covered with inhabited buildings is so much, there should be a greater allowance for more sparsely populated areas. Sewers carrying such relatively large volumes of surface and subsoil water will have their sewage contents so diluted as to render purification almost unnecessary. In this respect reference might be made to the samples taken during the night, October 28th, Table VIII., and during the night, November 19th, Table IX. On the latter date there was a flow of 9,000 gallons per hour during the whole night, and the character of the liquid was more that of subsoil water than of sewage. It must be remembered that most of the sewers in the Uddingston Drainage District were constructed in by-gone days under parochial administration, when the question of sewage purification received little consideration in connection with drainage districts, so that probably an unusually large amount of subsoil water enters these drains. In the planning of sewerage for new drainage districts, the Engineer has been careful to exclude road-surface water and subsoil drainage wherever possible. This is a matter of great importance, as it throws less strain upon the purification plant. Of course excessive volumes of land water have their compensations, not only in flushing the sewers, but also in diluting the sewage, which is thereby all the more easily purified by biological methods.

Filters.—The purification of water and sewage by filtration has long been practised, so that the erection of filters at the Uddingston Works must not be considered in the light of an experiment. There was, no doubt, at the time of their construction, room for inquiry as to the best filtering material to be used, the means employed for distributing the liquid over the filters, and as to the best method of working the filters, but that purification could be accomplished by such means was beyond doubt. The results obtained at these works show that from 50 to 60 per cent. of the dissolved organic impurities of sewage can be removed by a single treatment in a filter, and experiments made elsewhere show that, if this amount of purification is not considered sufficient, it can be increased by repeating the treatment in a second filter, and so on to any degree of purity that might be required.

With regard to material, furnace clinker, coke, and coal have been used at Uddingston, and experience shows that no appreciable difference between one filter effluent and another can be attributed to the filter material. In this connection, reference might be made to the analyses of samples taken on the 23rd October and 22nd November. There is, however, an important lesson to be drawn as regards the durability of filter material. The Engineer finds that the coal filter beds do not seem so durable as the furnace clinker beds. This is shown in the relative diminution in the capacity of the beds (See Table XII.). Probably the most durable material would be the small chips produced at whinstone quarries, *e.g.*, Dunduff gravel. The size of the particles of material and the grading of these in layers is also, probably, of not so much importance as was anticipated. For the attainment of the greatest amount of purification, we have found that the method of working the filters is all important. Upon the first-mentioned date we found that the average time taken to fill the filters was 1 hour 26 minutes; the time standing full, 52 minutes; the time occupied in emptying, 37 minutes; and that four of the filters were only once used during the working day, and one twice. This method of working filters is that known as "contact"—the sewage is held up in the filters until they are full, instead of being allowed to flow away as it enters. In experiments made elsewhere, the length of time the filters are allowed to stand full has generally been about two hours, but even in one hour we find the amount of purification attained may be quite satisfactory. The length of time occupied in filling the filter raises the question as to what is the most convenient size of filter, or what capacity each filter should have in relation to the hourly flow of sewage. Were the filtration continuous this would be a matter of less importance.

In order to ensure success, it is absolutely necessary to have the working of the filters attended to with the utmost care. Sewage works constructed on biological principles are probably more dependent for success upon the management than upon the particular method employed.

Tank.—This is perhaps the only part of the works that might be considered of an experimental nature, and yet the tank is little more than a magnified cesspool, although, at the time these works were constructed, much had been written and spoken of mysterious influences exerted by a covered tank in the purification of sewage. In summarising the results obtained at Uddingston, I have to admit that the examinations made were neither so frequent nor so exhaustive as I could have wished, but the results are so detailed that each one may form his own opinion.

Upon inspecting the works one sees that there is a marked contrast in the appearance of the sewage entering the tank and the effluent escaping therefrom. There is in the sewage a considerable quantity of large solid particles, carried along in the stream by the force of the current, or floating on the surface. These are never seen in the tank effluent. If a sample of sewage, excluding the gross solid particles just mentioned, be taken in a

glass vessel, one sees there is still a quantity of flocculent solid particles—which quickly subside—so that in an hour or so the sewage liquid contains only the finer solid particles, while the others are lying at the bottom of the vessel. If a sample of tank effluent be examined in a glass vessel, it is seen that it only contains the fine suspended particles. From such a simple examination we may conclude that all the suspended solids in sewage, except the finer particles, are retained in the tank; but these solids are all more or less soluble, and it is reasonable to suppose that, when retained in the tank, they will be acted upon by the sewage passing through the tank. Thus, if the liquid passing through the tank were almost free from suspended solids, and consisted chiefly of subsoil or land water, the solids in the tank would be more readily acted upon than when strong sewage was passing through the tank. In other words, when the liquid passing through the tank contains a considerable quantity of suspended solids, fresh additions will be made to the solids collected in the tank, whereas, when clear water only is entering the tank, it will, in passing through it, tend to dissolve, and, in that way, remove some of the solids collected in the tank.

The 10 samples of sewage taken during the night, October 28th, showed that the sewage was of a relatively weak character, almost free from suspended solids. On the 19th and 20th November sampling was continued over a period of 24 hours, and the results of analyses amply confirm the foregoing conclusions.

During the first three months the works were in operation there was little or no evidence of the accumulation of sludge in the tank, but subsequently one could, by pushing a rod to the bottom of the tank at either end, discover that sludge was accumulating. This condition was anticipated, as shown by the construction of a sludge pit and means for emptying the tank.

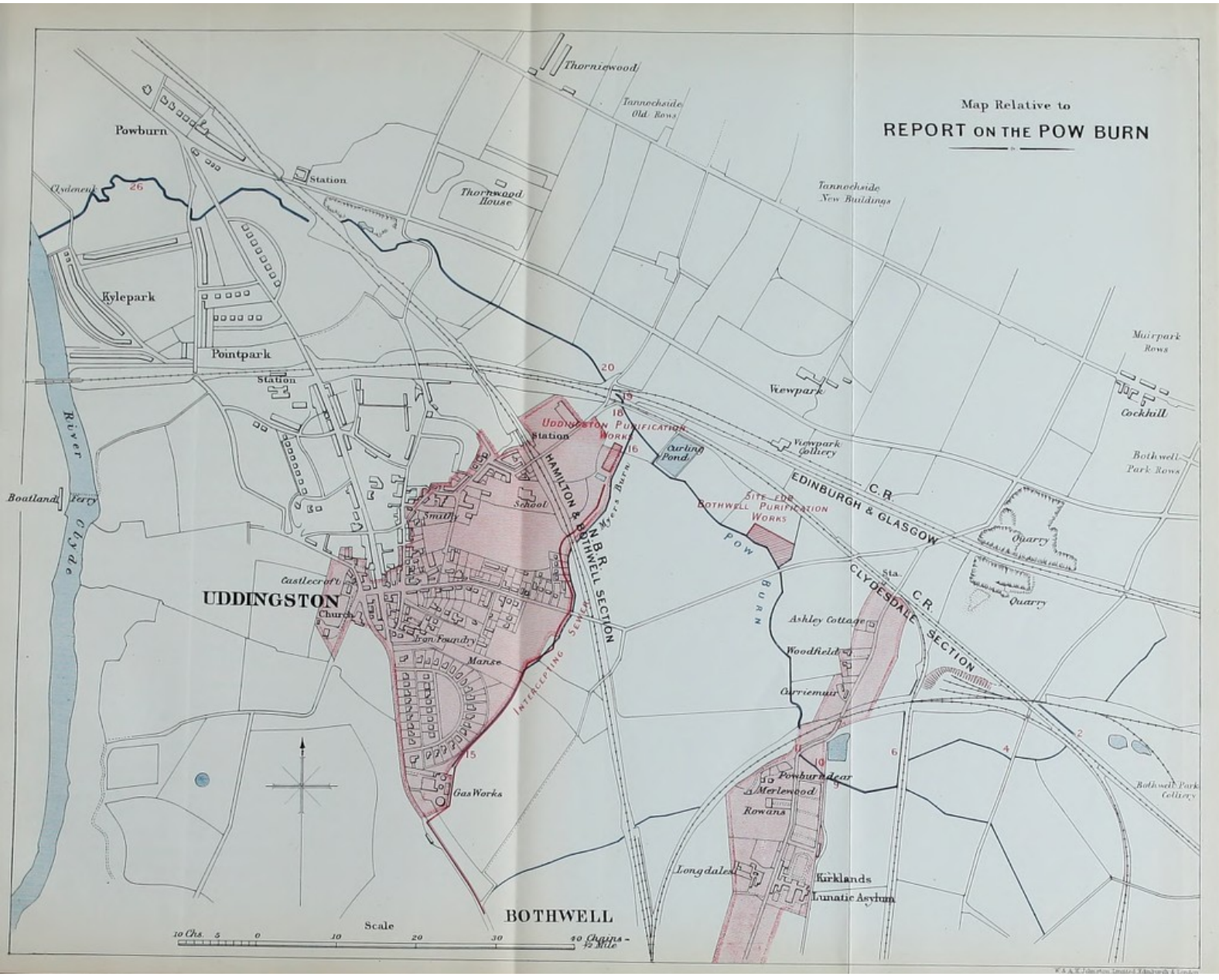
The analysis made shortly after the works had been set in operation, and before an accumulation of sludge was detected in the tank, led us to suppose that a considerable amount of purification was being effected by the tank, not only in the removal of suspended solids, but also in diminishing the amount of organic impurities in solution. This may have been so at the time when sludge had not accumulated in the tank to any extent, but subsequent experience showed that unless sampling had been continued for a period of 24 hours, it was not safe to draw any conclusion from a comparison of the sewage and tank effluent.

The analyses contained in Table IX. are particularly instructive in that respect. The 12 samples taken during the night show that the tank effluent contained more dissolved organic impurities than the sewage, while the samples taken during the day contained less. It is desirable that such sampling should be repeated and continued for more than one day, but, with the limited laboratory accommodation at present available, this has not been possible.

Extended experience will probably show that purely physical forces, such as sedimentation, diffusion, and solution, account for as much of the purification effected in the tank as the biological operations of sewage germs. The chief value of the tank seems to lie in the fact that it removes all the heavier suspended solids, it tends to equalise the hourly variations in the quality of the sewage, and prepares the sewage for the filter beds, where the chief purification of the dissolved solids takes place.

It is a matter for serious consideration whether it would not be desirable to clean out the tank at least once a year, about the month of March or April, as I believe in that way a better result would be obtained during summer weather.

NOTE.—Since these works were reported upon they have continued to give satisfactory results. The tank was emptied in May, 1902, and the amount of sludge taken out was, when dried, about 60 cubic yards.


Map Relative to
REPORT ON THE POW BURN
Thornywood
Tannochside Old Rows
Tannochside New Buildings
Powburn
Station
Clydeneuk
26
Thornwood House
Kylepark
Pointpark
Station
River Clyde
Boatland
Ferry
20
19
18
16
Uddingston Purification Works
Station
Viewpark
Viewpark Colliery
Curling Pond
Muirpark Rows
Cockhill
Bothwell Park Rows
C.R.
EDINBURGH & GLASGOW
Site for Bothwell Purification Works
POW BURN
Myers Burn
HAMILTON & B.N.B.R. BOTHWELL SECTION
Intercepting Sewer
Smithy
School
Castlecroft
UDDINGSTON
Church
Iron Foundry
Manse
Gas Works
15
Quarry
Quarry
Sta.
C.R.
CLYDESDALE SECTION
Ashley Cottage
Woodfield
Carriemuir
11
10
9
6
4
2
Powburndear
Merlewood
Rowans
Bothwell Park Colliery
Longdales
Kirklands
Lunatic Asylum
BOTHWELL
Scale
10 Chs. 5 0 10 20 30 40 Chains = ½ Mile

Part I.

REPORT ON THE POW BURN.

Description of Stream.

This small stream has, in the matter of prevention of pollution, received more attention than any other stream in the County. As the remedial measures adopted, and the procedure in dealing with offenders, afford examples of what can be, and has been, accomplished, it may be desirable to consider all these matters somewhat in detail. Special importance also attaches to this stream in respect that the first sewage works of any size constructed and worked on biological principles by the Middle Ward District Committee, were erected in this drainage area at Uddingston.

The Pow Burn rises in Bothwell Park High Wood, and drains an area about 1,540 acres in extent. On its way to the Clyde it is joined by several small nameless streams, and by one named the Myers Burn. In its course of $2\frac{3}{4}$ miles it is liable to pollution from a variety of sources, and the condition of the stream in 1899, when first inspected, was such as to render it quite unfit even for the purpose of a water supply for cattle. In the latter part of its course, where the stream flows through Uddingston, in close proximity to villa residences and public roads or places, it was so seriously polluted with sewage that in summer weather it became offensive, and was complained of as a nuisance.

Further information may be obtained from the map shewing the greater portion of the drainage area of the Pow Burn, with the more important places included therein.

Sources of Pollution, and the Measures adopted to prevent Pollution.

The more important sources of pollution are *eleven* in number. Each of these, along with the measures which have been adopted to obviate pollution, will be briefly referred to.

Bothwell Park Colliery.—The coal-dross washing plant is of the Robinson type, and has recently been provided with felspar boxes and a silt recovery tank, so that the water is used over and over again before being discharged. When it is necessary to empty the silt recovery tank for a fresh supply of water, the contents of the tank are pumped into an excavated pond on the top of a blaes bing, where it undergoes filtration. The drip from the waggons passes through settling ponds, where settlement of solid material takes place. Samples of effluent have frequently been

taken. These were at first of a greyish colour, but recently, owing to the improved arrangements above mentioned, the effluent has been clear and free from suspended solid matter (see Table, Sample No. 2).

Bothwell Park Rows.—There are 163 houses here. The amount of sewage is not great, as the conveniences are dry privy-ashpits, and the drainage is by surface channels, leading to a sewer ending in the Pow Burn. A sample was taken at the outfall into the burn (see Table, Sample No. 4). The owners of the houses have arranged either to adopt means to purify the sewage, or have it dealt with in a drainage district.

Drainage from Railway Embankment with Iron Pyrites.—This in wet weather is considerable in quantity, and of a yellowish colour. It is probably also at times of a poisonous nature, as vegetation, in the course of its flow in an open ditch, is destroyed. It cannot be said, however, that this drainage, which quickly changes its character, has any serious polluting effect on the Pow Burn (see Table, Samples Nos. 6 and 7). This is the only form of pollution which has come under my notice that seems not easily dealt with under the Rivers Pollution Prevention Acts.

Houses, Fallside Road and Kirklands Asylum.—There are several sewage discharges from these dwellings entering the stream (see Table, Samples Nos. 10 and 11). The Bothwell Special Drainage District has been extended so as to include all these properties, in order that public measures might be adopted for the prevention of pollution. Ground has been acquired for the erection of settling tanks and filters (see Map).

Uddingston and Bothwell Gas-works.—In August, 1901, spent ammoniacal liquor was found in the Myers Burn, and traced to these works. On inquiry, it was found that the Company had erected plant for the manufacture of sulphate of ammonia, and that no provision had been made for dealing with the spent ammoniacal liquor—a highly poisonous liquid, produced in great volume. For the first day or so, after the plant started working, the spent liquor was discharged into the Myers Burn; afterwards it was discharged into the public sewer, and thus affected the sewage works. As the gas-works are within the Uddingston Special Drainage District, the matter was then brought under the notice of the District Engineer, who informs me that the Company are making arrangements for disposing of the liquor at the works, but meanwhile it is being discharged into the Myers Burn.

Houses—Uddingston and Douglas Gardens (713), *and Kirkfield* (15).—For the purification of the sewage from these 728 houses, which form part of the Uddingston and of the Bothwell Special Drainage District, works were erected and completed in November, 1899, and have since been in operation, with satisfactory results. See Special Reports by the District Engineer and by the Medical Officer.

Vale of Clyde Preserve Works.—The discharge from these works contains a large quantity of fruit pulp. They are situated within the Uddingston Special Drainage District, and steps are being taken to have the drains connected to a sewer discharging into the sewage works.

Viewpark Colliery.—A "Luhrig" washing plant is in operation at this colliery, using the water over and over again for about a fortnight, when the settling tanks are cleaned out and started again with clean water. When this is done, the dirty water is run off into a large brick pond. It is then pumped into excavated ponds formed on the top of a blaes bing, through which it filters, and is again caught on the ground level and filtered through land. Any drip from waggons, or other escape of water from the washer during working hours, is also pumped to the blaes bing. The first samples taken showed a small amount of suspended solids, but now, as a result of improvements carried out, the effluent is clear.

Tannochside Rows.—A drainage district was formed to include these houses which discharged sewage into the Pow Burn just below Spindlehowe Road Bridge. Arrangements have been made to connect this outfall with the Uddingston drainage system, and thus obviate pollution of the Pow Burn.

Slaughter-house at Old Quarry.—Pollutions occur here after the slaughtering of cattle, the drainage containing much animal matter. There is also at times an accumulation of garbage at the side of the burn, which may be affected thereby. The erection of a public slaughter-house for Bothwell Parish at Bellshill is, however, under consideration, and when these premises are available, the abolition or disuse of existing private slaughter-houses in the parish will follow.

Villas at Clydeneuk.—The drains of two villas at Clydeneuk discharge into the stream near its outfall to the Clyde. These houses are within the Uddingston Special Drainage District, and will be connected to the low-level outfall sewer.

The condition of the stream and the nature of the various pollutions affecting it may be gathered from the annexed Table, showing the samples which have been taken, and the results of analyses and examination.

THE POW BURN—SAMPLES TAKEN ON NOVEMBER 28TH,* 1900, AT

The sources of pollution

No.	NATURE OF SAMPLES AND PLACES WHERE TAKEN.
1	Streamlet—One origin of Pow Burn,
2	Pipe, 9-inch, Effluent from Bothwell Park Colliery, joining No. 1,
3	Pow Burn, below junction of No. 1 and No. 2,
4	Sewer Outfall from Bothwell Park Rows,
5	Pow Burn, immediately below No. 4,
6	Ditch—Drainage from embankment containing iron pyrites,
7	Pow Burn, about 10 yards below No. 6,
8	Streamlet joining Pow Burn,
9	Pipe, 9-inch, beside Fallside Road,
10	Sewer from Kirklands Asylum,
11	Sewer from houses on Fallside Road,
12	Pow Burn, immediately below No. 11,
13	Streamlet joining Pow Burn immediately below No. 12,
14	Pow Burn, about 500 yards below No. 13, after junction of clear ditch,
15	Outlet from Uddingston and Bothwell Gas-works to Myers Burn,
16	Myers Burn, below outlet from Uddingston Sewage Works,
17	Pow Burn, below junction of Myers Burn,
18	Pipe, 6-inch, from Vale of Clyde Preserve Works,
19	Outlet from Viewpark Colliery,
20	Pow Burn, below Tannochside Sewage Outfall,
21	Pipe, 6-inch,
22	Pow Burn, before entering Old Duck Pond,
23	Pow Burn, after leaving Old Duck Pond,
24	Pipe, 9-inch,
25	Pipe, 6-inch, below No. 21,
26	Drains from villas at Clydeneuk,
27	Pow Burn, at outfall into Clyde,

* The only exceptions are Samples No. 15, taken on 13th August;

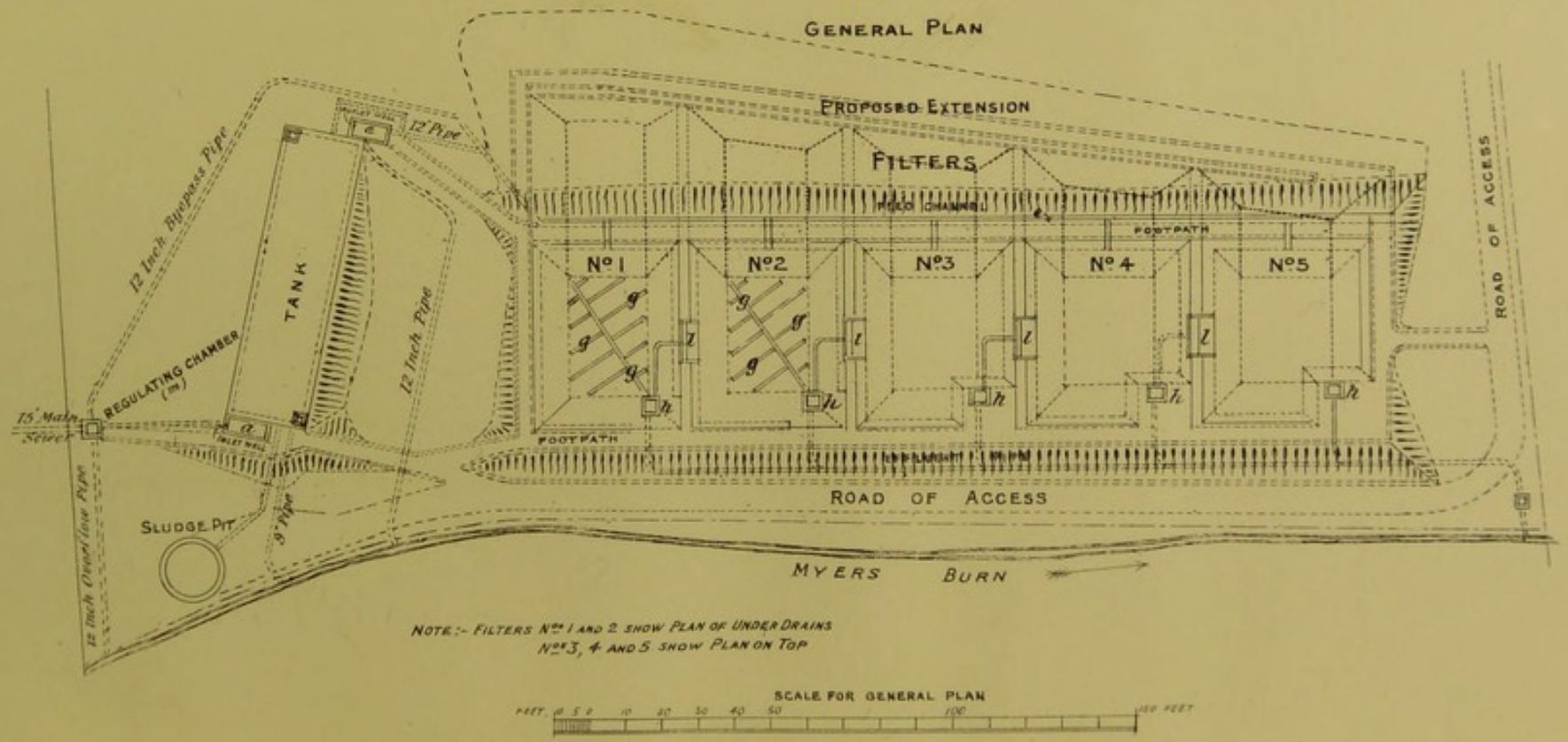
VARIOUS POINTS IN ITS COURSE AND FROM ITS AFFLUENTS.

are in bold type.

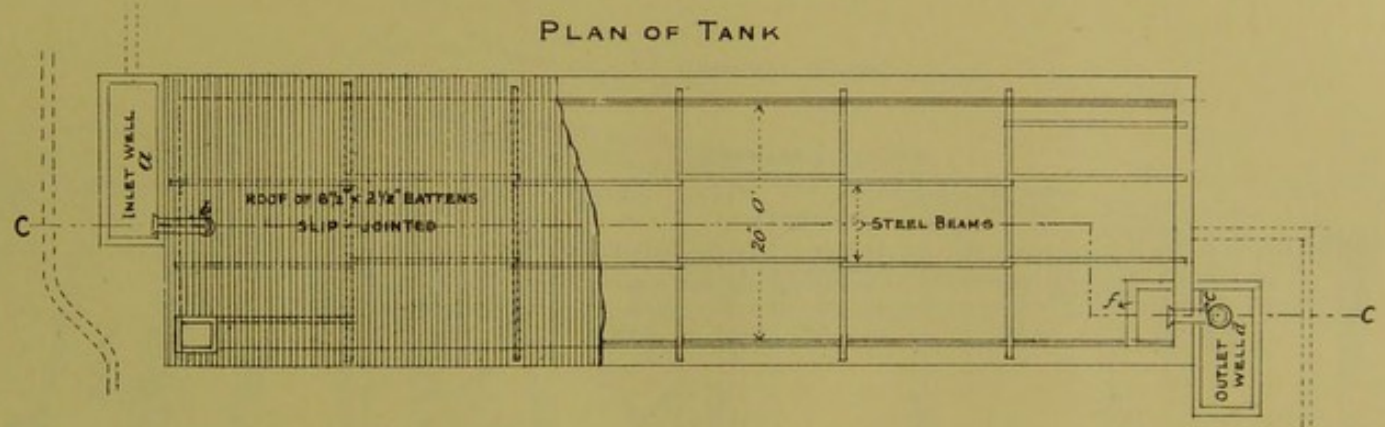
CHEMICAL ANALYSES. (Results stated in Grains per Gallon.)			PHYSICAL CHARACTERS OF SAMPLES AFTER STANDING OVER 12 HOURS.
Chlorides.	Free Ammonia.	Oxygen absorbed in 4 hours at 80° F.	
1·0	·84	·29	Clear and transparent.
4·3	**·98**	**·75**	Greyish in colour, due to fine particles of clay.
1·7	·84	·20	Clear and sufficiently transparent to read type, but not distinctly.
6·6	**2·31**	**1·12**	Not transparent, type not even seen ; deposit flocculent and of a dark grey colour.
2·2	·84	·62	
1·4	·63	·13	After standing was clear and transparent, but contained a deposit of a yellow colour and granular appearance.
1·8	·63	·25	
1·0	·77	·30	Clear and transparent.
1·3	·49	·44	Clear and transparent ; probably surface drainage.
5·0	**1·47**	**1·63**	Appearance of dilute crude sewage.
3·8	**1·33**	**·90**	Appearance of dilute crude sewage, with small deposit of flocculent matter.
2·2	1·12	·42	Greyish in colour ; type visible through it ; small deposit.
2·4	·49	·37	Clear and transparent, but had small deposit of granular material.
2·0	·70	·26	Clearer than No. 12.
4·3	**19·00**	**373·**	Dark brownish-red coloured liquid, with strong odour of coal tar.
2·7	**1·26**	**·77**	Greyish-brown in colour.
2·2	1·12	·57	
2·0	...	**9·2**	Pink-coloured liquid, with 105 grains per gallon of solids in suspension.
2·7	...	**0·36**	Dark opaque liquid, with 32 grains per gallon of solids in suspension.
2·1	1·12	·59	
1·9	1·12	·26	Clear liquid ; probably subsoil drainage.
2·1	1·12	·38	
2·0	1·19	·37	
1·9	·70	·35	Clear liquid ; probably subsoil drainage.
1·5	·35	·15	Clear liquid ; probably subsoil drainage.
...	...	...	
2·0	1·05	·37	

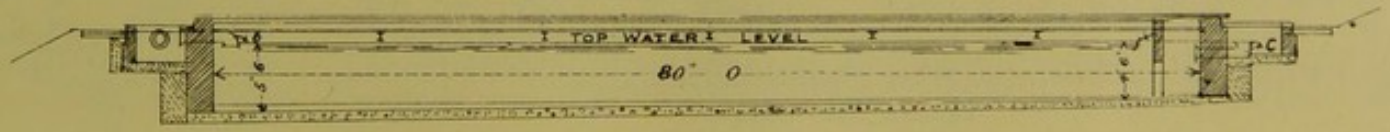
No. 18, taken on 4th September ; and No. 19, taken on 1st June, 1901.

UDDINGSTON SEWAGE PURIFICATION WORKS.



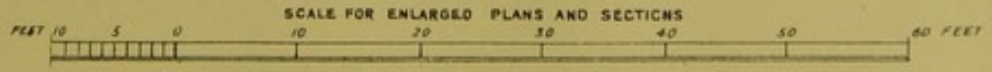
PLAN OF TANK

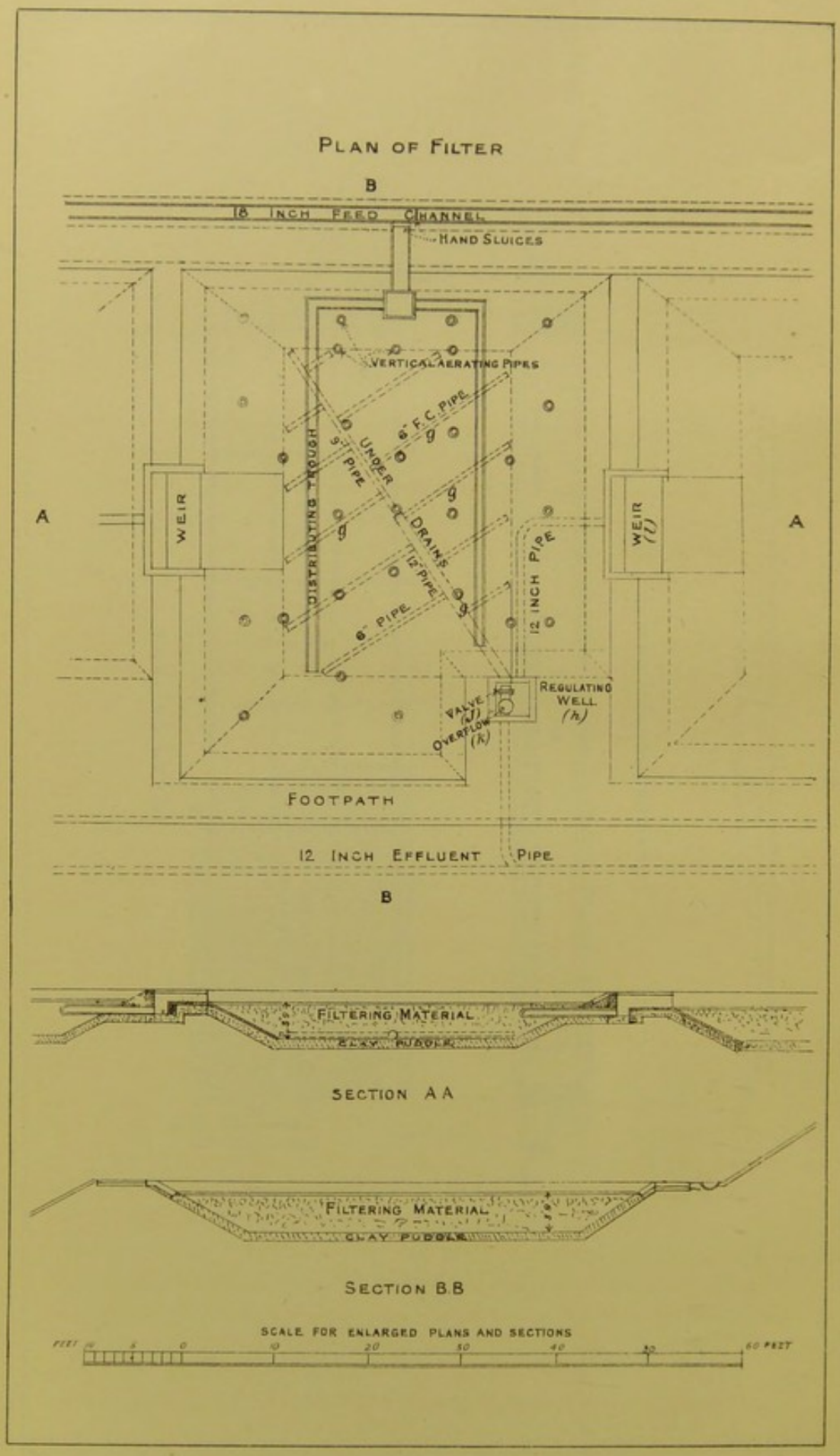




LONGITUDINAL SECTION C.C.

SCALE FOR ENLARGED PLANS AND SECTIONS




PLAN OF FILTER
B
18 INCH FEED CHANNEL
HAND SLUICES
VERTICAL AERATING PIPES
6" F.C. PIPE
UNDER DRAINS
9" PIPE
DISTRIBUTING TROUGH
12 PIPE
6" PIPE
12 INCH PIPE
WEIR
WEIR (l)
A
A
REGULATING WELL (h)
VALVE (j)
OVERFLOW (k)
FOOTPATH
12 INCH EFFLUENT PIPE
B
FILTERING MATERIAL
CLAY PUDDLE
SECTION A A
FILTERING MATERIAL
CLAY PUDDLE
SECTION B B
SCALE FOR ENLARGED PLANS AND SECTIONS
FEET
60 FEET

PART II.

UDDINGSTON SEWAGE PURIFICATION WORKS.

DESCRIPTIVE REPORT BY THE DISTRICT ENGINEER.

18th November, 1901.

These works were constructed for the purpose of purifying the sewage discharged into the Pow Burn from the south-eastern portion of the Uddingston Special Drainage District, and the Kirkfield portion of the Bothwell Special Drainage District.

The area of the two districts draining into the works extends to 111 acres, and the length of public and private roads included therein is 6,160 yards. The dwelling-houses number about 728, a considerable number of which are villa residences. There are besides 2 public works and about 7 stables and cowsheds. The population is estimated at 3,320, and the water consumpt at 91,200 gallons per day, which is rather less than 28 gallons per head.

The works were designed by Messrs. Crouch & Hogg, C.E., and were constructed of such a size as was considered sufficient to deal with the amount of sewage which, from the information at their disposal, it was estimated would be discharged at the works under normal conditions.

In order to convey the sewage to the works an intercepting sewer, about three-quarters of a mile in length, had to be constructed, to which were connected all the sewers which were discharging their contents into the Myers Burn at various points along its course.

To avoid sending an unnecessarily large volume of water through the works in time of heavy rain, storm overflows were constructed at suitable points along the line of the intercepting sewer, and from these the storm water is discharged into the nearest stream.

The purification works, which are situated near the junction of the Myers Burn with the Pow Burn, consist of a covered tank and five filters.

The tank is 80 feet long by 20 feet broad; its depth to top-water level is 5 feet 6 inches at the inlet end and 4 feet 6 inches at the outlet end, its capacity being 47,600 gallons. The floor is formed of a layer of cement concrete, and the walls of brickwork built in cement, while the roof is formed of whitewood battens creosoted and slip-jointed with wrought-iron fillets. There is a grit chamber or inlet well (*a*) on plan annexed to this report, 12 feet long by 4 feet 3 inches broad by 18 inches deep, at the east end of the tank, the sewage passing from this well into the tank by means

of a cast-iron pipe (*b*) built through the east wall of the tank. This pipe is turned downwards on the inside of the tank so as to allow it to deliver its contents below top-water level. The effluent finds its way out of the tank by means of a cast-iron pipe (*c*) built through the west wall at the north-west corner of the tank. This pipe discharges into an outlet well (*d*), from which the effluent passes through a fire-clay pipe to the feed channel (*e*), and thence to the filters. The feed channel is fitted with hand sluices, by which the supply to each filter can be regulated. A scum wall (*f*), with an opening in it about 1 foot below top-water level, is built in front of the outlet pipe from the tank in order to prevent the scum which forms on the top of the water in the tank finding its way into the outlet pipe.

A little to the east of the tank there is a sludge pit connected with the tank by a pipe fitted with a valve at its upper end, through which any sludge which may accumulate in the bottom of the tank can be discharged into the pit.

The filters are five in number, and are constructed of earthwork, the floors and sides being lined with a layer of clay puddle.

Each filter is 3 feet 9 inches deep, and has a mean area of 139 square yards.

Three different kinds of filtering material, namely, coal, coke, and ordinary furnace clinker, are used in the filters. The composition of each filter is given in the following table:—

TABLE SHOWING THE CHARACTER OF THE FILTERING MATERIAL USED, WITH THE DEPTH AND SIZE FROM ABOVE DOWNWARDS IN EACH CASE.

Filter No. 1—Clinker.			Filter No. 2—Coke.			Filter No. 3—Coke.			Filter No. 4—Coal.			Filter No. 5—Coal.		
Depth.		Size.	Depth.		Size.	Depth.		Size.	Depth.		Size.	Depth.		Size.
Ft.	Ins.	Ins.	Ft.	Ins.	Ins.	Ft.	Ins.	Ins.	Ft.	Ins.	Ins.	Ft.	Ins.	Ins.
—	3	½ to ¼	—	3	½ to ¼	—	3	½ to ¼	—	3	Single Nuts.	—	3	Single Nuts.
1	2	¼ ,, ⅛	2	—	¼ ,, ⅛	1	2	¼ ,, ⅛	1	9	Pearls above ⅛	2	—	Pearls.
1	2	½ ,, ¼	—	6	½ ,, ¼	1	2	½ ,, ¼	—	8½	Singles under ½	—	7	Singles under ½
1	2	¾ ,, ½	1	—	¾ ,, ½	1	2	¾ ,, ½	1	0½	Singles over ½	—	11	Singles over ½
3	9	—	3	9	—	3	9	—	3	9	—	3	9	—

To drain the filters several lines of fireclay pipes (*gg*), with open joints, were laid along the floors. These discharge the contents of the filters into

regulating wells (*h*) fitted with the necessary valves (*j*) and overflow pipes (*k*), from which the effluent is discharged into a fireclay pipe and thence into the Myers Burn.

In order to give an opportunity of trying various methods of treating the effluent from the tank in the filters, weir chambers (*l*) were constructed between each filter, and pipes laid from the regulating well of each filter to the weir chamber between it and the filter immediately to the north. By this means the effluent from one filter could be passed through one or more of the other filters if necessary.

On arrival at the works the sewage passes through a regulating chamber (*m*) fitted with penstock sluices and storm overflow weir, by which the amount to be sent through the works can be regulated. From this chamber it passes to the tank, and from the tank to the filters.

During the daytime the filters are worked on the contact system—that is to say, each filter is filled in rotation with the effluent from the tank, and allowed to stand full for some time. The contents are then drawn off, and the filter is allowed to stand empty for some time before it is used again. Each filter is allowed one full day's rest in every five, so that only four filters are in use at one time.

During the night the effluent from the tank is passed continuously through one filter.

The works were completed and operations commenced on 26th November, 1899.

Soon after the works were put into operation it was found that the volume of sewage discharged at the works was, especially in wet or showery weather, considerably in excess of what was anticipated, and that, although the results obtained from analysis showed that the works were capable of producing a satisfactory effluent, they could not deal efficiently with the whole of the sewage.

Instructions have been recently given by the Committee of Management to have the works extended. These proposed extensions are shown in dotted lines on the plan.

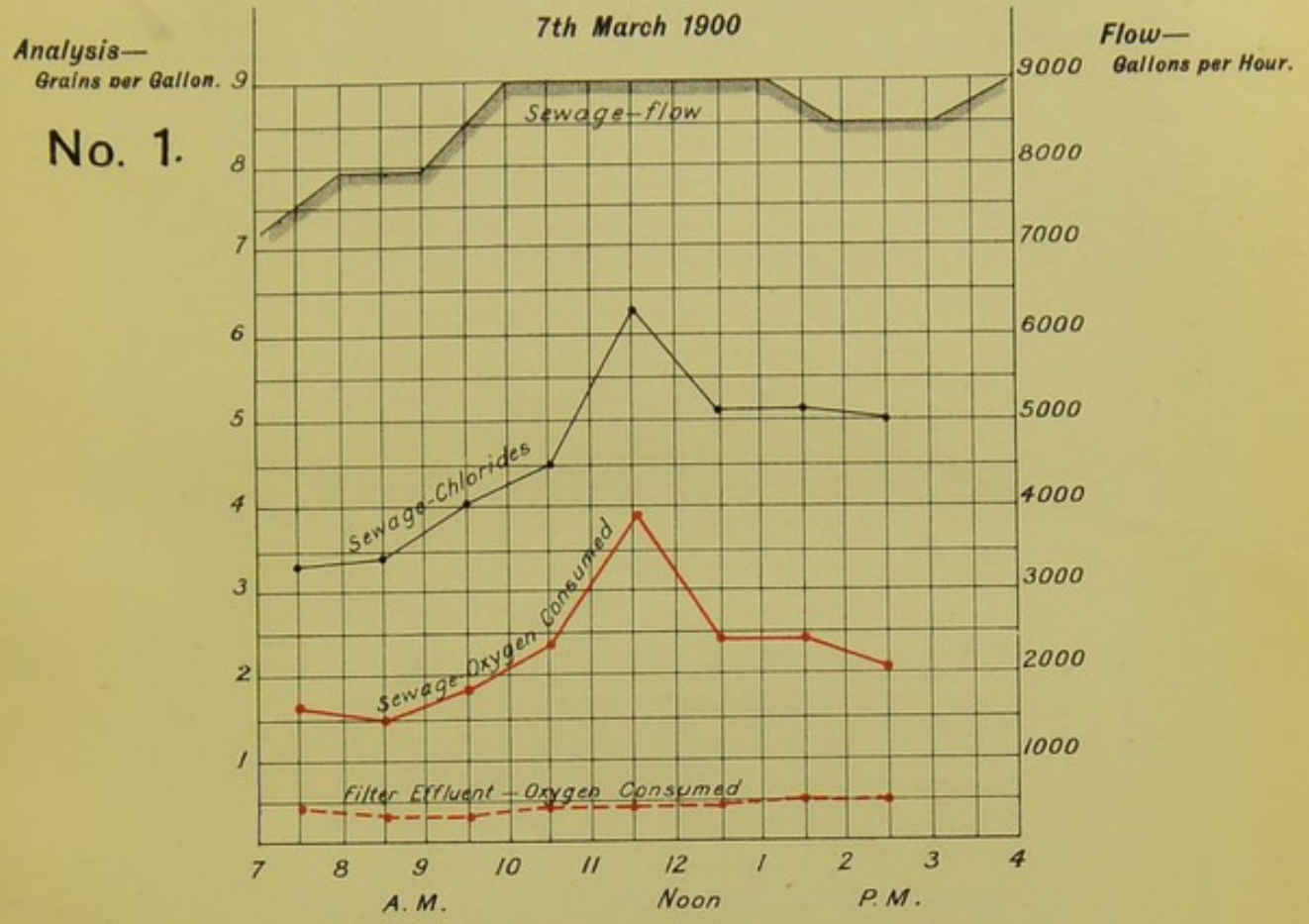
From careful measurements, which were made night and day, of the sewage discharged at the works, it has been found that during a period from 30th June to 10th August, 1901—

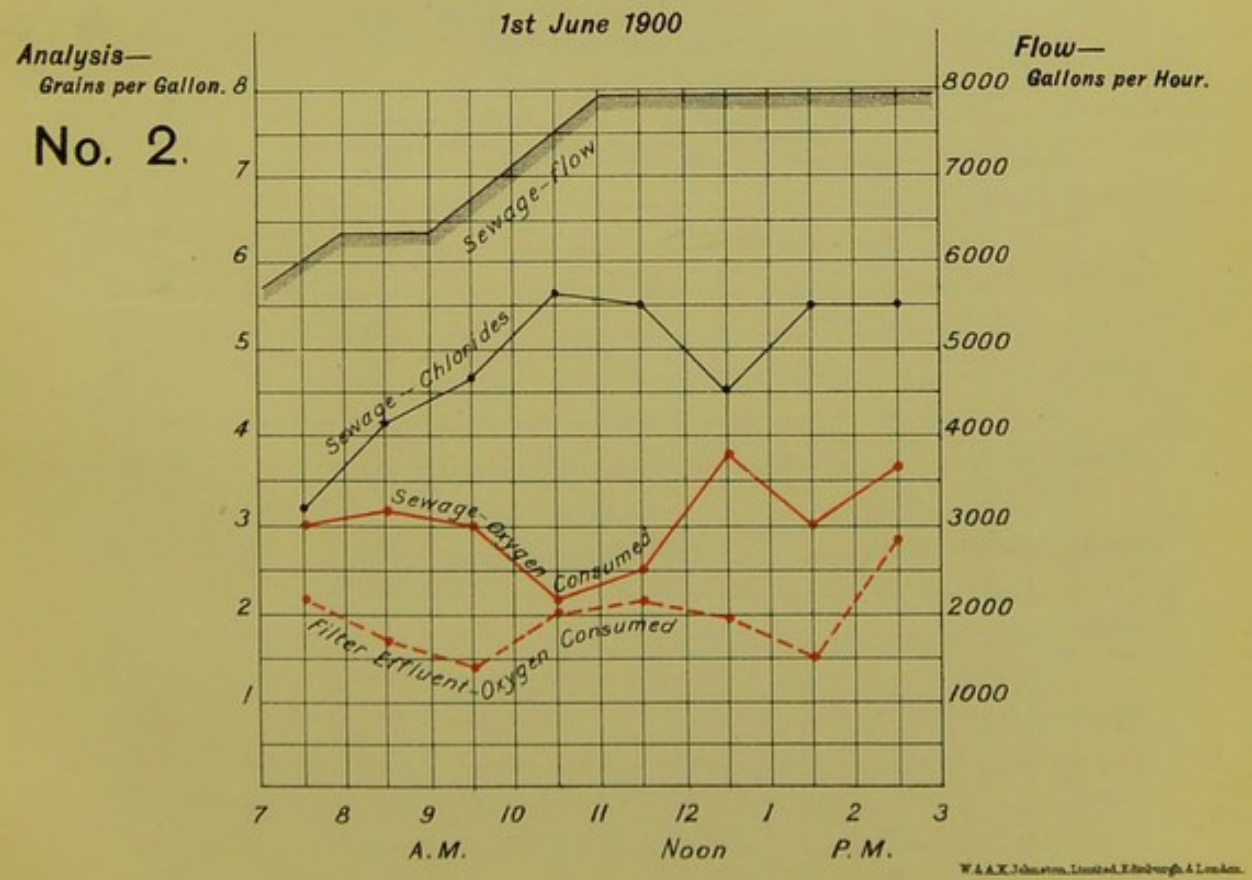
	Gallons.
(1) The maximum flow of sewage for a day of 24 hours was	142,687
(2) The minimum " " "	85,650
(3) The average " " "	107,100
(4) The average flow for 12 hours, from 6 a.m. to 6 p.m., was	62,500
(5) The average maximum flow in one hour, 1-2 p.m., was	5,894
(6) The average minimum flow in one hour, 1-2 a.m., was	2,437

See also Diagram No. 5, showing the average daily flow of sewage discharged at the works between 1st July and 10th August, 1901.

The weekly rainfall for these six weeks was as follows:—Week ending 6th July, 0·05 in.; 13th, 0·00 in.; 20th, 0·40 in.; 27th, 1·35 in.; 3rd August, 0·00 in.; 10th, 1·06 in.—the total for the six weeks being 2·86 inches, and the average less than half-an-inch per week.

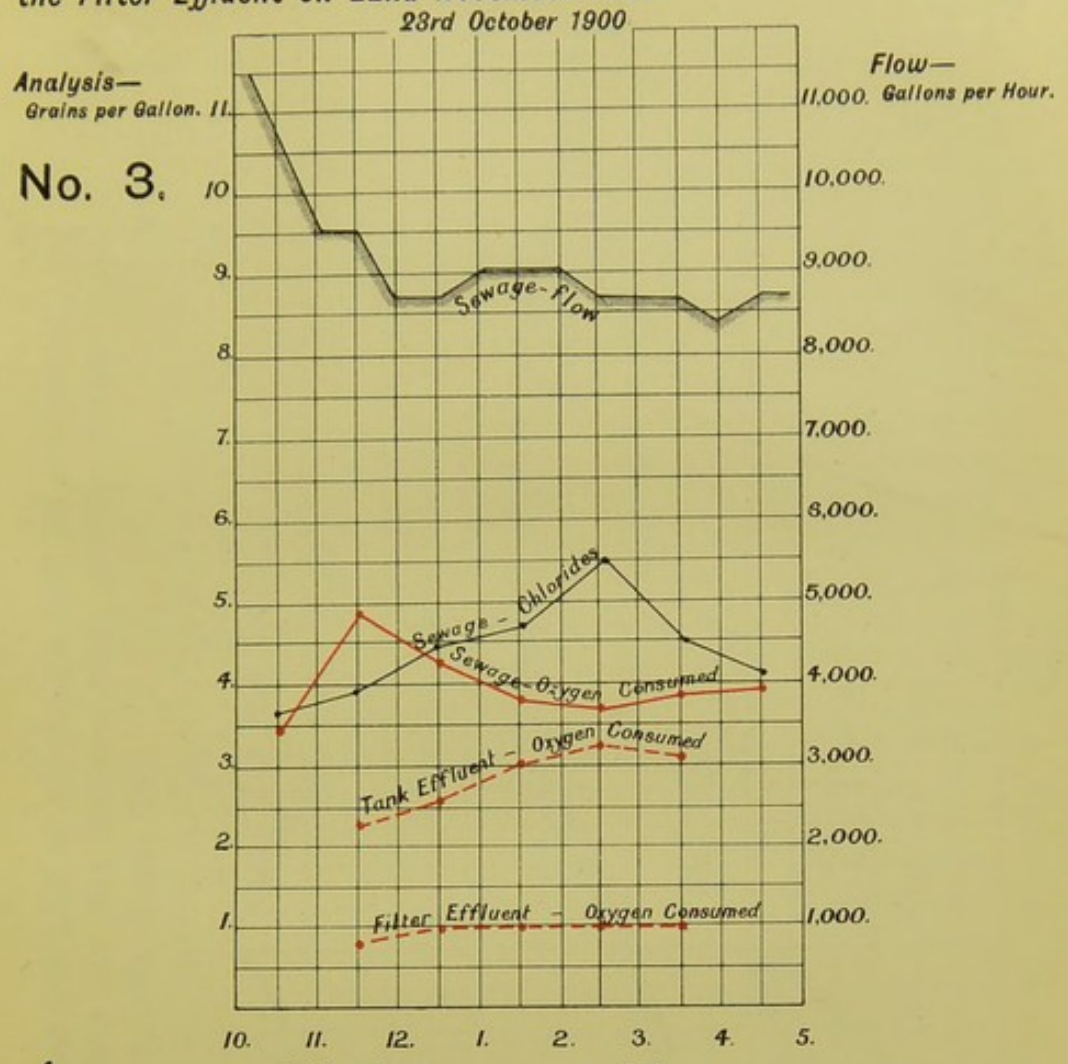
DIAGRAMS shewing the Flow and Character of the Sewage and the Character of the Filter Effluent.

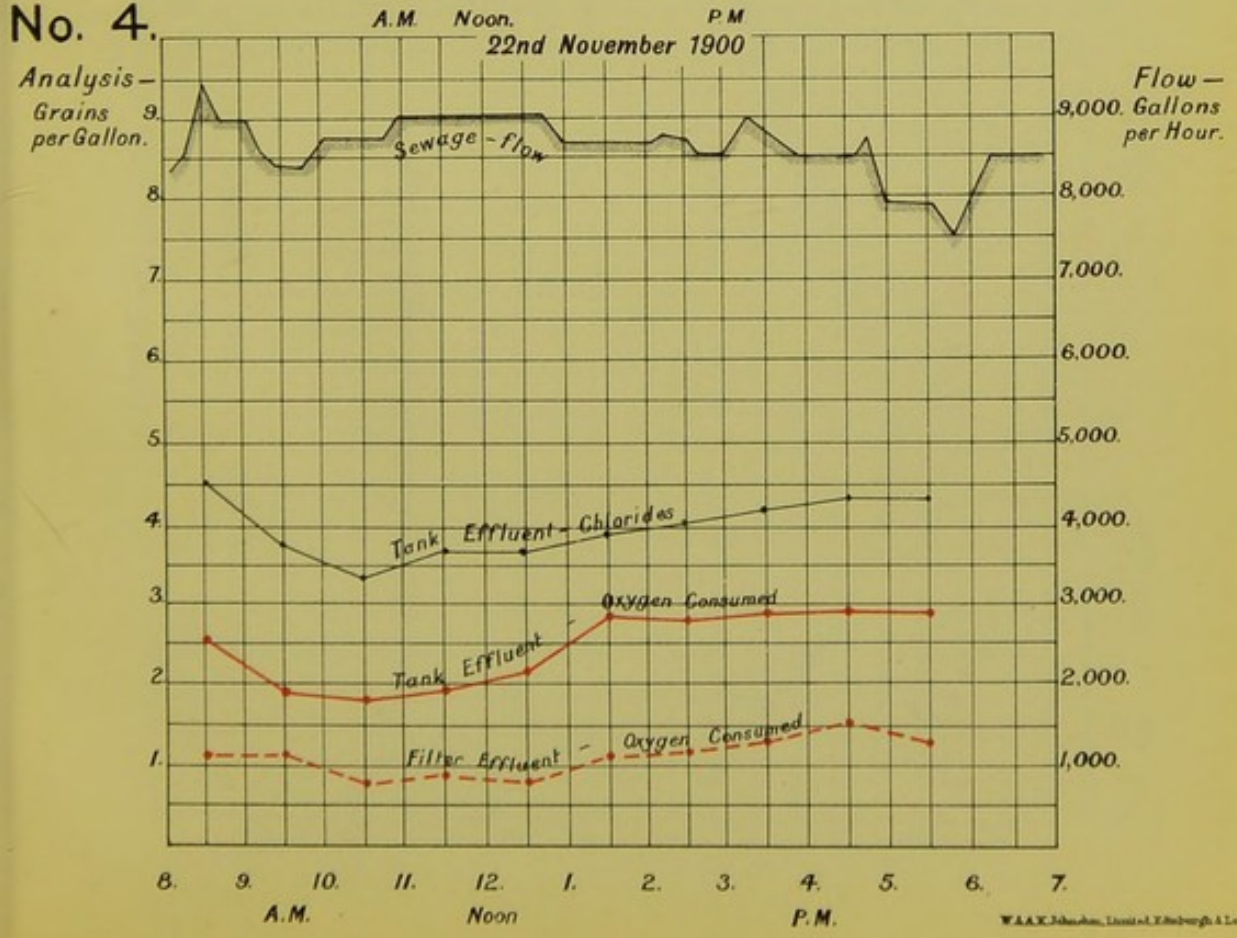


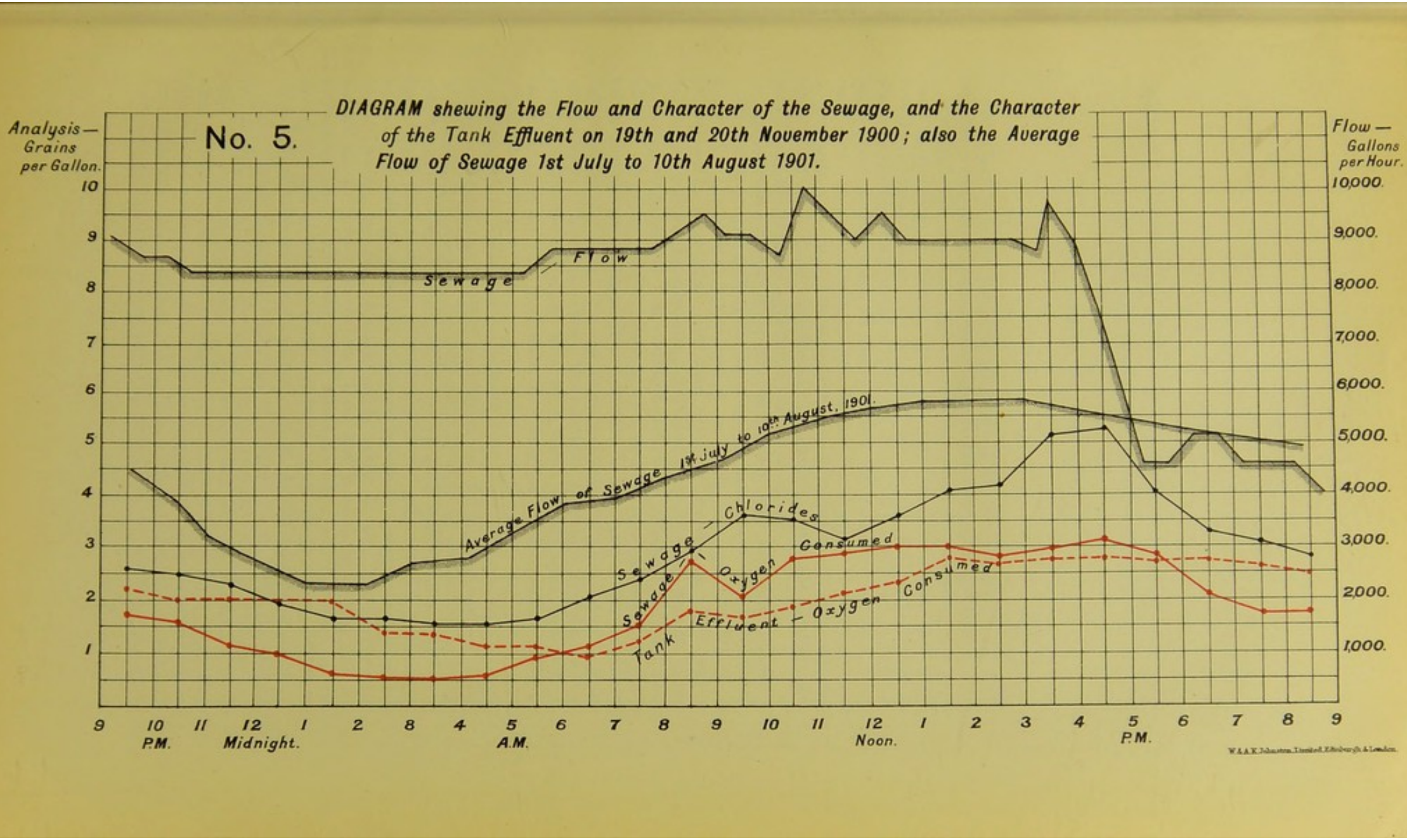


W. & A. K. Johnston, Limited, Edinburgh & London.

DIAGRAM No. 3 shewing the Flow and Character of the Sewage, and the Character of the Tank and Filter Effluents on 23rd October; and No. 4 shewing the Sewage Flow and Character of the Tank Effluent and of the Filter Effluent on 22nd November 1900.






No. 5.
DIAGRAM shewing the Flow and Character of the Sewage, and the Character of the Tank Effluent on 19th and 20th November 1900; also the Average Flow of Sewage 1st July to 10th August 1901.
Analysis — Grains per Gallon.
Flow — Gallons per Hour.
10
9
8
7
6
5
4
3
2
1
10,000.
9,000.
8,000.
7,000.
6,000.
5,000.
4,000.
3,000.
2,000.
1,000.
Sewage Flow
Average Flow of Sewage 1st July to 10th August, 1901.
Sewage — Chlorides
Sewage — Oxygen Consumed
Tank Effluent — Oxygen Consumed
9 10 11 12 1 2 8 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9
P.M. Midnight. A.M. Noon. P.M.

PART III.

REPORT AND ANALYSES OF SAMPLES EXAMINED IN THE PUBLIC HEALTH LABORATORY,

During the Year 1900.

7TH MARCH.—The samples taken on this date consisted of eight samples crude sewage, eight tank effluent, and eight filter effluent.

Diagram No. I. shows that at 7 a.m., when the sampling was commenced, the flow of sewage was at the rate of 7,000 gallons per hour, that by 10 a.m. it had risen to 9,000 gallons, and that it continued at this rate during the greater part of the day. The results of analysis of each sample are recorded in Table I. and also on the diagram. These show that the sewage was weakest in the morning, gradually increased in strength, and that the sample taken just before midday was the strongest of all. These variations in the quality of the sewage were also manifest in the physical appearances of the samples.

An average sample of crude sewage, of tank and filter effluents, having been prepared from the eight hourly samples of each, these were analysed. The results are recorded in Table II., and are briefly as follows:—The total solids (the solid matter suspended in the liquid or visible, as well as the substances dissolved in the liquid) present in one gallon of each sample was—Sewage, 72; tank effluent, 40; and filter effluent, 28 grains. After allowing the samples to stand for a day, the solids in suspension settled to the bottom of the vessel. On estimating the solids in the liquid we find in each sample 30, 22, and 16 grains respectively. There was thus a considerable reduction in both the suspended and dissolved solids of sewage found in the tank and then in the filter effluents, the total reduction being in the proportion of 72 to 28, or about 60 per cent.

Although it would not be safe to base upon the analyses of eight hourly samples any general conclusion as to the amount of solids intercepted day by day, it is of some interest to make the following calculation:—If the flow of sewage be taken at 8,000 gallons per hour, that would amount in the 10 hours to 80,000 gallons; and if, as shown by the analyses, 44 grains of solids per gallon of sewage are intercepted at the works, 460 lbs. of dried solids would in that time have been carried in the sewage to the Pow Burn had it been discharged into the stream without purification. But solids do not exist in sewage in the dry state, but as sludge, which contains about 90 per cent. moisture; therefore, 460 lbs. of solids represent ten times that amount of sludge.

The dissolved organic impurities in sewage are of great importance, and are estimated under the two chemical factors—"Oxygen Consumed" and "Albuminoid Ammonia." The estimations as recorded in the Table are:—Oxygen consumed—sewage, 2.3; tank effluent, 1.4; and filter effluent, 0.4 grains per gallon. The corresponding figures for albuminoid ammonia are 1.3, 0.8, and 0.5. These results show a considerable reduction in the dissolved organic impurities, and are all to be considered

very satisfactory; yet anyone who has seen the effluent from sewage works where purification is effected by chemical treatment, might, on looking at the effluent as it leaves the Uddingston filters, be disappointed, because it generally is at first less transparent than the effluent obtained by chemical treatment. The cloudiness, however, soon disappears in the effluent from the Uddingston Works. It improves upon standing, whereas the effluent from chemical processes, unless discharged into a stream of much larger volume than the sewage, may become offensive.

As the keeping power of sewage effluents is a matter of much importance, it was considered desirable to make some observations in the laboratory in connection with these samples. Only a small portion of the samples having been used for analyses, they were retained in the laboratory for the purpose of observing any physical changes they might undergo. At the end of a week all the samples—sewage, tank and filter effluents—had a scum on the surface, formed by germ growth. This scum was most marked in the sewage and least in the filter effluent. Considerable changes went on in the various samples, and at the end of about three months the alterations in appearance were again recorded.

The two samples of weak sewage had become quite transparent, undergoing self-purification even while standing in a stoppered bottle. All the other samples were turbid and of a foul character, showing that sewage of an average strength, although kept for either a short or a long period in a closed vessel, cannot purify itself. The samples of tank effluent were all, except one, quite transparent and free from any offensive odour. The samples of filter effluent were also quite transparent and free from any offensive odour, except No. 4.

1st June.—The number of samples taken on this date was, as on the previous occasion, eight sewage, eight tank, and eight filter effluent. The physical appearances were somewhat similar to those of the previous samples, and the amount of solids was not estimated. Average samples for the day were made up, and the analyses are given in Table IV., while the results of analysis of the separate samples are given in Table III. (See also Diagram No. 2.)

The reduction in dissolved organic matter effected in the sewage in its passage through the works is indicated by the figures 3.0, 2.6, and 1.9, given under "Oxygen Consumed," while the reduction, as indicated by the "Albuminoid Ammonia" figures, was 0.6, 0.5, and 0.2.

The samples were kept in the laboratory for four weeks. At the end of the first week the sewage samples were found to be still turbid and opaque, to have a heavy deposit of solids, and an odour of domestic sewage, very strong and sulphurous in two samples at the end of the series. The tank effluent samples were all turbid, but, as in the sewage, the first four of the series were less so than the others. The deposit of solids was very much less than in the sewage, and the odour was less marked. The filter effluent was, in the first four samples, quite clear and transparent, and in the last four slightly turbid. There was very little deposit and no odour characteristic of sewage in any of the samples. At the end of the third week the samples of sewage and tank effluent had not improved in any way. The samples of filter effluent were now all quite clear and transparent, and were still free from any odour of sewage. At the end of the fourth week the sewage samples, Nos. 5 to 8, were still turbid and had a strong, offensive sewage odour. The tank effluent samples 5 to 8 had a distinct sewage odour, whereas in the samples

of filter effluent there was still no odour of sewage, and in only one sample was there any perceptible odour at all.

By thus comparing the physical appearances of the crude sewage with those of the filter effluent, it would be easy to convince anyone that considerable purification had taken place. Even if one compared the first four samples of crude sewage, taken early in the day (which were the best of the series) with the last four samples of filter effluent, the contrast is very apparent, especially as regards the transparency, deposit, and odour.

Subsequent to 1st June, inspection of the tank contents, so far as permissible, showed that a considerable deposit of sludge was accumulating, especially at or near the inlet end. About 15th August the Engineer, having reason to suspect that the works were not producing a satisfactory effluent, took three samples on that date. The weather had been previously warm and wet. The results of analyses are given in Table V., and show that the sewage was very strong and that little or no purification was being effected. The figures were:—

Oxygen consumed,	-	Sewage,	4·6	T.E.,	4·1	F.E., 3·6
Albuminoid Ammonia,		,,	0·3	,,	0·5	,, 0·3

When examined again on the 17th, it was found that all these samples were much worse, the oxygen consumed being much higher. On 23rd August three samples were again submitted, but the results did not show any great improvement.

I have no desire to give any undue prominence to these unsatisfactory results, but as I believe they afford valuable information, especially as to the influence of the tank and the method of working the filters, it would be folly to ignore them. Besides, they are the only unsatisfactory results we have to record.

On the 29th September a sample of effluent submitted for analysis only absorbed two grains of oxygen per gallon.

23rd October.—The sampling on this date, and the examinations which followed, were specially planned with a view to determine, separately, the influence of the tank upon the sewage and of the filters upon the tank effluent. There had been little or no rainfall for a week, yet the flow of sewage, shown in Diagram No. 3, varied from 11,500 to about 8,500 gallons per hour.

One important function attributed to the tank is the removal of solids in suspension. To what extent does the tank do so is a most important question. Watching the sewage outfall at the well where the samples were taken, one could frequently see gross solids carried in the sewage such as are discharged from a water-closet or slop sink. These in sampling are generally excluded, and as they are never seen in that form at the tank outlet we must assume they are retained by the tank, but how they are disposed of we have yet to determine. In the samples of sewage taken for analysis we find that, on standing for a few hours, the larger and heavier particles in the suspended solids fall to the bottom of the vessel, while the liquid remains turbid from the presence of fine particles in suspension. These heavier particles seem also to be removed in the tank as they are not seen in the tank effluent.

It seemed to me it would be of interest to determine the amount of solids that could be separated by sedimentation, *i.e.*, by simply allowing the sewage to settle. The method by which this was carried out is detailed in the Appendix—"Document No. 1."

The results might be summed up thus:—Four bottles, with about two and a quarter gallons (2.37) of sewage, were allowed to stand for about 18 hours. The solids which fell to the bottom of the vessel were removed, and when dried weighed altogether 19.8 grains. This seemed a rather small amount of dried solids in such a quantity of sewage, and I had hoped to repeat the experiment, but it will be remembered the sewage in these samples was not strong. Of the solids removed by sedimentation, 76 per cent. fell within two hours, the remaining 24 per cent. in sixteen hours, and the liquid in the samples still remained turbid, showing there was still some fine solids in suspension. Having regard to the length of time an average flow of sewage takes to pass through the tank, we may conclude from this experiment that about 75 per cent. of the heavier suspended solids is removed by sedimentation, and will be retained in the tank. Further, that so far as this mechanical process is concerned, it would be of little advantage to retain the sewage for a longer time in the tank, although the amount of solids still suspended in fresh sewage after 18 hours settling may be considerable.

A complete estimation of the amount of solids in a sample of sewage and corresponding sample of tank effluent was also made on this date. The results were as follows:—

	Crude Sewage. Grains per Gallon.	Tank Effluent. Grains per Gallon.
Solids in Suspension, - - -	52·5	42·7
,, Solution, - - -	32·2	39·2
Total, - -	84·7	81·9

It is difficult to say how far the sample of tank effluent represents the sewage, but in view of the sedimentation experiment, it is interesting to note that the difference in the amount of suspended solids in the tank effluent from sewage was 9.8 grains per gallon; and that the amount of dissolved solids in the tank effluent was 7 grains per gallon more than in the sewage. The results are in marked contrast to those obtained in the samples taken on 7th March, when the works had only been about three months in operation.

To estimate the work done by the filters, samples of tank effluent were taken during the whole time each filter was filling, and thus an average sample was obtained with which the effluent from each filter could be compared. By mixing a small portion of all the tank and filter effluents, samples for the day were prepared. The results of analyses are recorded in Tables VI. and VII. The amount of purification effected by the filters upon the tank effluent by the removal of dissolved organic impurities was from 50 to 60 per cent. Thus the oxygen consumed in the tank effluent was 2.5 grains, and in the filter effluent 1 grain per gallon; the albuminoid ammonia figures were 0.37 and 0.17 respectively. If the analyses of the filter effluent be compared with the crude sewage, the reduction in oxygen consumed will be found still higher.

Regarding physical appearances, the five samples of tank effluent were all slightly turbid and not sufficiently transparent to see type through the liquid. The first and last samples were not quite so turbid as the others. The amount of deposit was not marked, and was of a granular character; it adhered to the sides and covered the bottom of the vessel. All the samples had a brownish tinge, and no odour characteristic of sewage.

The filter effluent samples varied in appearance. No. 1 was sufficiently transparent to read type through the liquid; in sample No. 2 the type

was only faintly visible, and in the other three could not be made out. The amount of deposit was small. The colour of the liquid was greyish, and none of the samples had any odour characteristic of sewage. Several of the samples contained vermiform animals, about an inch long, swimming about with a snake-like movement.

28TH OCTOBER.—With a view to still further elucidate the action of the tank, I thought it desirable to take samples of crude sewage during the night on this date, commencing at 9 p.m. and ending at 7 a.m. The flow of sewage during this period is not known to the Engineer, but the results of analyses are very instructive. The amount of chlorides and of oxygen consumed in each of the 10 samples estimated will be found in Table VIII., and show that the night samples were all very weak. The amount of chlorides present in the sewage during the whole ten hours averaged 1.8, while the oxygen consumed averaged 1.5 grains per gallon, but in most of the night samples the oxygen consumed was little over one grain per gallon.

As one grain per gallon of oxygen absorbed in sewage effluents has been talked of as a permissible limit of impurity, and as the samples do not contain any appreciable quantity of suspended solids, and have an odour more suggestive of sub-soil water than sewage, the total flow to the works between the hours of 9 p.m. and 7 a.m. might be discharged direct to the burn at the storm overflow. These results show it would be desirable to take further samples, not only of sewage, but also of tank effluents during the night, and to continue sampling over a period of twenty-four hours; and the flow should also be measured at the same time.

19TH AND 20TH NOVEMBER.—The series of average hourly samples taken on this occasion comprised 24 sewage and 24 tank effluent, commencing at 9 p.m. on the 19th, and concluding at 9 p.m. on the 20th. The results of analyses are given in Table IX. There had been no rain for three days, and for the week ending 17th November the rainfall was about one inch.

Looking at Diagram No. 5, we observe that the sewage flow for the twenty-four hours was almost uniformly about 9,000 gallons per hour up till 5 p.m., when it suddenly fell to 4,500 gallons per hour. I have put on this diagram also the average daily flow, as ascertained by the Engineer, during the period 1st July to 10th August, 1901, the only time during which a continuous record of flow was taken at the works. The variations in the strength or quality of both sewage and tank effluent are also represented on the diagram. The sewage analyses show that the chlorides and oxygen consumed varied somewhat in conformity with the average and not the actual daily flow. Thus, commencing at 9 p.m., the curves gradually decline, and are at their lowest from about 1 to 5 a.m. There is then a gradual rise during the day till about 5 p.m., when the decline again commences.

The tank effluent analyses are represented only by the oxygen consumed, and it will be observed that while the contour of the line follows generally that of the sewage, it is not subject to such great fluctuations—that is to say the tank effluent is more uniform in quality. The range of figures in Table IX. are:—For sewage—chlorides, 1.6 to 5.3; oxygen consumed, 0.6 to 3.2; and for tank effluent — Chlorides, 1.7 to 4.4; oxygen consumed, 1.0 to 2.8.

Notice in particular that for about one-half of the twenty-four hours the tank effluent is stronger and for the other half weaker than the sewage. From between 5 and 6 in the morning to the same hour in the evening the tank effluent is weaker, or contains less organic matter in solution, whereas the night flow of tank effluent is stronger than the sewage.

Knowing the flow of sewage, we are now able to determine the extent of purification effected in the tank by the removal of dissolved organic impurities. Generally the flow of sewage during the day is, in the absence of rainfall, much greater than that during the night, but it so happens that on the date in question the flow was almost uniform except during the last four hours. We might, therefore, in estimating the purification effected by the tank, simply take the average analyses of all the hourly samples, assuming that the volume of sewage was equal throughout. These averages are given in Table IX., and show that in the sewage the chlorides was 3.0 and the oxygen consumed 1.5, whereas in the tank effluent the chlorides was 2.9, and the oxygen consumed 2.0. We are therefore forced to admit that the average amount of dissolved organic matter in the tank effluent exceeded that in the crude sewage, and that in this respect no purification was effected by the tank. But the removal of suspended solids was effected as on all former occasions.

The greater portion of the night sewage flow was so weak that it could have been discharged into the stream without going through the works; the amount of oxygen consumed by most of the night samples being under one grain per gallon.

The physical appearances of these samples corresponded with the results of analyses. Thus sewage samples 1 to 12—the first and the last of the night series—were the strongest, whereas those in the middle of the series had no appearance of sewage. These were quite transparent, type being quite easily read on looking through the samples. They had little or no deposit, nor had they any colour or odour of sewage. Indeed, they might have passed for samples of water for domestic purposes. The night samples of tank effluent differed in appearance from the sewage in that they had all more or less a greyish opalescent appearance, although those in the middle of the series were sufficiently transparent to read type through the liquid. They had no distinctive odour of sewage.

The day samples—Nos. 13 to 24—were very different from the night ones. Thus, sewage samples Nos. 13 to 24 were quite turbid, type not even being visible on looking through the samples. Nos. 16 to 20 were the least transparent of all. The series might be described as increasing in strength from No. 13 to No. 19, and then gradually tapering off, No. 13 being the weakest of all. The colour of those in the middle of the series was yellow, and in the others pale grey. There was no perceptible odour in any of the samples, although they had all the appearance of fairly strong sewage.

The differences in appearance observed in the sewage were not by any means so marked in the tank effluent; still the samples seemed to gradually increase in strength, commencing with No. 13, up to No. 20, and then falling off. They were not transparent, type not being visible. All the samples had a greyish opalescent appearance except Nos. 17 to 23, which had a yellowish tinge. There was no distinctive odour in any of the samples.

From all this we may conclude that the tank at this date was not causing any diminution in the amount of dissolved organic substances in the sewage, but that it had an equalising effect, as seen on the smoothing

of the curve of quality—oxygen consumed (Diagram No. 5). During the night, when weak sewage or only sub-soil water was entering the tank, the stronger sewage or sludge in the tank imparted by diffusion and solution a stronger character to the liquid. During the day, when the sewage was strong, the weaker sewage in the tank had a diluting effect. If we were to compare only samples of sewage and tank effluent taken during the day, the results would be very misleading as regards the work done by the tank. If we take the average of the night samples and the average of the day samples, the results of analyses are as follows:—

Samples No.	Crude Sewage.		Tank Effluent.	
	Chlorides.	Oxygen Consumed.	Chlorides.	Oxygen Consumed.
1-9 and 22-24	2·3	1·2	2·8	1·9
10-21	3·7	2·6	3·1	2·2

Sampling, therefore, only during the day period, would show the tank to be removing dissolved solids, whereas, during the night it was adding to the dissolved solids in the sewage. Again, if a comparison were made between the crude sewage and the filtrate of the day samples, the results would also be misleading. To estimate the work done by the filters, a comparison should be made between the filter effluent and the tank effluent it received. The work done by the tank and the work done by the filters must be estimated separately. No period less than twenty-four hours is of any value in estimating tank purification, whereas, each filter filling forms a record in itself of the work it does.

22nd November.—Ten samples of tank effluent and ten of filter effluent were taken on this date. Average samples of sewage were also taken in order to show the strength or quality on that particular date. The flow was pretty equal, varying from 7,500 to 9,500 gallons per hour. (See Diagram No. 4.) The results of analyses are recorded in Tables X and XI. Comparing the solids in the sewage with those in the tank effluent during this period, we find that the total solids in the sewage was 79, and in the tank effluent 64, grains per gallon. After being allowed to settle for some time, the solids were again estimated. They were—in the crude sewage 35 and in the tank effluent 29. The diminution in the total solids of the tank effluent, amounting to 15 grains per gallon, probably represents the suspended solids actually removed and retained by the tank, but, as already explained, in order to be certain of this, the sampling should have extended over a period of twenty-four hours.

Comparing the tank effluent and filter effluent, which was the chief object in taking the samples, we find that the average amount of purification effected, as represented by the oxygen consumed, was 55 per cent., and as represented by the albuminoid ammonia, 45 per cent., the actual figures being—tank effluent, oxygen consumed, 2.2, and albuminoid ammonia, 0.35; filter effluent, oxygen consumed, 1.0, and albuminoid ammonia, 0.19 grains per gallon. In the analyses of the separate samples of filter effluent, it will be observed that in several the oxygen consumed was under one grain per gallon.

None of the samples of tank effluent were transparent, type not being visible. In some of the samples the amount of deposit was considerable. All the samples were grey in colour and had no distinctive odour.

All the samples of filter effluent were quite transparent, type being readable, but the first five samples were more transparent than the others. A very small deposit was seen lying in the bottom of the vessels. All the samples were pale grey in colour and had no distinctive odour.

7TH DECEMBER.—With a view to obtaining some further information as to the length of time sewage might take in its passage through the tank, the following experiment was planned and carried out on this date. (The flow during the experiment varied from 11,000 to 10,000 gallons per hour):—

A cloth bag containing about 2 lbs. of a dye—aniline green—was placed at the inlet to the tank at 11.15 a.m. and retained there till 12.5 p.m. By this means all the sewage entering the tank during these 50 minutes was dyed a green colour. Watch was kept, and samples frequently taken at the outlet of the tank, with the following result:—At 11.50 the dye was first visible. At 12 the colour was very distinctly seen. At 12.15 it had attained its maximum depth of colour. At 1.5 p.m. the colour was diminishing; and at 1.40 it had greatly faded, but was still visible up to 3 o'clock.

Comparing the maximum depth of colour at the outlet with the colour of the sewage at the inlet, one could see there was a great loss of colour in its passage through the tank, due, no doubt, to diffusion in the tank.

We may conclude from this experiment, that when such a volume of sewage is entering the tank it reaches the outlet within an hour. At 11.15 the dye was added to the tank inlet; at 12.15 the colour of the tank effluent had reached its maximum depth. At 12.5 the dye was removed from the inlet; and at 1.5 the colour was fading from the effluent.

Assuming that the flow was in the same volume as during the experiment, the character of the sewage entering the tank at any particular time would in 35 minutes begin to affect the outlet. About an hour after its effect upon the tank effluent would be most felt, then these influences would gradually diminish.

This concludes the investigation as regards the sewage works.

During the year 1901 the investigations made concerned mainly the Pow Burn and the various effluents affecting it, but samples from the sewage works were sometimes submitted by the Engineer and sometimes taken by the Inspectors for analyses. Thus, on 27th March, samples of tank and of filter effluents were examined. The oxygen consumed by the tank effluent was 2.24, and by the filter effluent 1.5 grains per gallon. After being kept for two days at a warm temperature, and again examined, the oxygen consumed was only 2.1 and 1.0, showing that the samples had improved by keeping. There was also in the filter effluent abundance of nitrates—0.3 grains per gallon.

On 15th May, two samples were taken. The oxygen consumed by the tank effluent was 2.3 and by the filter effluent 0.9 grains per gallon. The nitrates in the filter effluent was 0.5 grains per gallon. The sewage on this day was very strong.

On 17th May, two samples were taken. The oxygen consumed by tank effluent was 2.5 and by filter effluent 0.6 grains per gallon.

On 7th June, three samples of filter effluent were taken. In two the oxygen consumed was 1.2 and in one 1.5 grains per gallon.

On 8th August, in a sample of tank effluent, 3.7, and in a sample of filter effluent 1.5 grains per gallon of oxygen was consumed.

INSPECTIONS OF THE POW BURN DURING 1901.

The outfall from the sewage works discharges into the little stream known as the Myers Burn just before it joins the Pow Burn. If, therefore, samples be taken from the Pow Burn a few yards above the junction of the Myers Burn, and compared with the samples taken below the junction, the effect of the sewage works effluent upon the Pow Burn will be readily detected. The following samples were taken for that purpose:—

			Chlorides.	Oxygen Consumed.
May 21—Pow Burn	above	Sewage Works, -	2·2	·33
,,	below	,, -	2·6	1·2
July 13— ,,	above	,, -	2·1	·23
,,	below	,, -	2·9	·62
Aug. 8— ,,	above*	,, -	2·7	·85
,,	below	,, -	3·2	1·0
,, 13— ,,	above*	,, -	1·7	2·0
,,	below	,, -	2·2	2·6
Dec. 17— ,,	above†	,, -	2·0	1·8
,,	below	,, -	2·2	1·25

* Lower down the stream a slight odour was detected from it.
† Stream was in spate and had a muddy appearance.

On the last date the stream was more polluted above than below the sewage works, but on all the other dates the Pow Burn was purer above the works.

Noxious Trade Liquids.

Surface water from the highway and drainage from the fields through which the Myers Burn flows was, until recently, the only drainage other than the sewage works affecting it, but the gas-works now discharge intermittently spent liquor.

This highly poisonous liquid was on one occasion discharged into the public sewer, and thus affected the sewage works. The effect is shown in the following analyses of samples taken on 13th August:—Oxygen consumed by sewage, 45.0; by tank effluent, 36.0; and by filter effluent, 10.0 grains per gallon.

The conditions under which such a noxious liquid shall be admitted to a public sewer are so far regulated by statute, and, as the matter is of great importance, I would take this opportunity of quoting various enactments relative thereto.

Reference might also be made to an important decision in the Court of Session under these statutes—reported in the *Scots Law Times* of 29th December, 1900,—Cowie & Son *v.* the Commissioners of Dufftown.

Public Health (Scotland) Act, 1897, Section 110, entitles any owner or occupier of premises to cause his drains to empty into the sewers of

the Local Authority, on certain conditions, which do not seem to exclude such liquors. The following statutory provisions seem, however, to apply:—

Public Health (Scotland) Act, 1897, Section 116.—"The owners or occupiers of distilleries, manufactories, and other works shall be compelled, where possible, to dig, make, and construct pools or reservoirs within their own ground, or as near their works as possible, for receiving and depositing the refuse of such works so far as offensive or injurious or dangerous to the health of those living in the vicinity thereof, or to **use the best practicable means for rendering the same inoffensive or innoxious before discharging it into any river, stream, ditch, sewer, or other channel.**"

Rivers Pollution Prevention Act, 1876, Part IV., Section 7.—"Every sanitary or other local authority having sewers under their control shall give facilities for enabling manufacturers within their district to carry the liquids proceeding from their factories or manufacturing processes into such sewers;

Provided that this section shall not extend to compel any sanitary or other local authority to admit into their sewers any liquid which would prejudicially affect such sewers or the disposal by sale, application to land, or otherwise, of the sewage matter conveyed along such sewers, or which would from its temperature or otherwise be injurious in a sanitary point of view;

Provided also that no sanitary authority shall be required to give such facilities as aforesaid where the sewers of such authority are only sufficient for the requirements of their district, nor where such facilities would interfere with any order of any court of competent jurisdiction respecting the sewage of such authority."

For comparison, I quote the provisions applicable to trade refuse in the City of Glasgow and to any sewers or drains connecting with the Corporation sewers. These provisions would presumably apply to those portions of the Lower Ward District provided for in the statute quoted.

Glasgow Corporation (Sewage, &c.) Act, 1898, Section 30.—"It shall not be lawful for any person to send or permit to flow or pass into any sewers of the Corporation authorised by the Acts of 1891 and 1896 and this Act, or into any sewers or drains connecting therewith, any liquid substance or matter which would be injurious to the construction, maintenance, use, or efficiency of such sewers or of any sewage works of the Corporation, or which would cause, or be likely to cause, silting up, corrosion, or decay of the materials of such sewers or works, or to interfere with the efficient treatment of the sewage passing through such sewers; and every person offending against this enactment shall, for every such offence, be liable, on summary conviction by the Sheriff, to a penalty not exceeding ten pounds, and a further penalty, not exceeding five pounds, for every day during which the offence is continued after conviction thereof. Section 28 of the Act of 1896 is hereby repealed."

Tables of Analyses, &c., referred to in the Report.

TABLE I.—AVERAGE HOURLY SAMPLES OF CRUDE SEWAGE, TANK EFFLUENT, AND FILTER EFFLUENT TAKEN DURING THE DAY OF 7TH MARCH, 1900, COMMENCING WITH SEWAGE AT 7 A.M., TANK EFFLUENT AT 8 A.M., AND FILTRATE AT 11 A.M.

Chlorides and Oxygen consumed. Results stated as grains per gallon.

Sample No.	Sewage.		Tank Effluent.		Filter Effluent.		Filter No.
	Chlorides.	Oxygen Consumed.	Chlorides.	Oxygen Consumed.	Chlorides.	Oxygen Consumed.	
1	3·3	1·7	3·0	1·1	3·5	0·4	1
2	3·4	1·5	3·1	1·0	3·4	0·3	2
3	4·0	1·8	3·2	1·2	3·5	0·3	3
4	4·5	2·4	3·5	1·2	3·7	0·4	4
5	6·3	3·8	4·2	1·4	4·0	0·4	5
6	5·1	2·5	4·4	1·8	4·0	0·4	1
7	5·1	2·5	4·5	1·7	4·1	0·5	2
8	5·0	2·2	4·5	2·0	4·2	0·5	3
Average	4·6	2·3	3·8	1·4	3·8	0·4	

TABLE II.—AVERAGE SAMPLES OF SEWAGE AND EFFLUENTS PREPARED FROM THE ABOVE FOR MORE COMPLETE ANALYSIS.

	Crude Sewage.	Tank Effluent.	Filter Effluent.
Chlorides, - - - -	4·8	4·0	3·8
Oxygen Consumed, - -	2·3	1·4	0·4
Free Ammonia, - - -	3·0	2·7	2·4
Albuminoid Ammonia, -	1·3	0·8	0·5
Nitrites, - - - -	Abundant.	Trace.	Distinct trace.
Nitrates, - - - -	...	Trace.	Abundant.
Solids (Total), - - -	72	40	28
Solids (after settling), -	30	22	16

These Samples were shaken up before estimating the Ammonias.

TABLE III.—AVERAGE HOURLY SAMPLES OF CRUDE SEWAGE, TANK EFFLUENT, AND FILTER EFFLUENT TAKEN DURING THE DAY OF 1ST JUNE, 1900, COMMENCING WITH SEWAGE AT 7 A.M., TANK EFFLUENT AT 8, AND FILTRATE AT 9 A.M.

Chlorides and Oxygen consumed. Results stated as grains per gallon.

Sample No.	Sewage.		Tank Effluent.		Filter Effluent.		Filter No.
	Chlorides.	Oxygen Consumed.	Chlorides.	Oxygen Consumed.	Chlorides.	Oxygen Consumed.	
1	3·3	3·1	2·9		3·4	2·2	1
2	4·2	3·3	3·2		3·7	1·7	2
3	4·7	3·0	3·4		3·0	1·4	3
4	5·6	2·2	4·0		3·8	2·0	4
5	5·5	2·5	4·4		4·2	2·2	5
6	4·5	3·8	4·5		4·0	1·9	1
7	5·5	3·0	4·7		4·0	1·5	2
8	5·5	3·6	5·0		4·5	2·8	3
Average	4·8	3·0	4·0		3·8	1·9	

TABLE IV.—AVERAGE SAMPLES OF SEWAGE AND EFFLUENTS PREPARED FROM ABOVE FOR MORE COMPLETE ANALYSIS.

	Sewage.	Tank Effluent.	Filter Effluent.
Chlorides, - - - -	4·8	4·0	3·8
Oxygen Consumed, - -	3·0	2·6	1·9
Free Ammonia, - - -	4·0	2·9	1·5
Albuminoid Ammonia, -	0·6	0·5	0·2
Nitrates, - - - -	*Nil.*	*Nil.*	Abundant.

TABLE V.—A SAMPLE OF CRUDE SEWAGE, OF TANK EFFLUENT, AND OF FILTER EFFLUENT TAKEN ON THE AFTERNOON OF 15TH AUGUST, 1900.

Results of Analyses stated as grains per gallon.

	Sewage.	Tank Effluent.	Filter Effluent.
Chlorides, - - - -	8·4	7·0	4·9
Oxygen Consumed, - -	4·6	4·1	3·6
Free Ammonia, - - -	1·3	1·7	2·4
Albuminoid Ammonia, -	0·3	0·5	0·3
Nitrites, - - - -	...	...	...
Nitrates, - - - -	...	...	Faint trace.

TABLE VI.—AVERAGE HOURLY SAMPLES OF CRUDE SEWAGE, TANK EFFLUENT, AND FILTER EFFLUENT TAKEN DURING THE DAY OF 23RD OCTOBER, COMMENCING WITH TANK EFFLUENT AT 7 A.M. AND SEWAGE AT 10 A.M.

Chlorides and Oxygen consumed. Results stated as grains per gallon.

Sample No.	Crude Sewage.		Tank Effluent.		Filter Effluent.		Filter No.
	Chlorides.	Oxygen Consumed.	Chlorides.	Oxygen Consumed.	Chlorides.	Oxygen Consumed.	
1	3·7	3·6	3·0	2·3	...	...	...
2	3·9	4·8	3·0	2·6	3·4	0·8	2
3	4·4	4·3	3·8	3·1	3·2	1·0	3
4	4·7	3·8	4·2	3·3	3·3	1·0	4
5	5·5	3·7	4·2	3·2	3·5	1·0	5
6	4·5	3·9	...	...	3·0	1·0	1
7	4·1	4·0	...	...	...	...	2
Average	4·4	4·0	3·6	2·9	3·1	0·9	

TABLE VII.—AVERAGE SAMPLES OF SEWAGE AND EFFLUENTS PREPARED FROM ABOVE FOR MORE COMPLETE ANALYSIS.

	Sewage.	Tank Effluent.	Filter Effluent.
Chlorides, - - - -	4·0	3·4	3·1
Oxygen Consumed, - -	3·9	2·5	1·0
Free Ammonia, - - -	0·8	0·8	0·5
Albuminoid Ammonia, -	0·36	0·37	0·17
Nitrites, - - - - -	...	...	Abundant.
Nitrates as N., - - -	...	...	0·6
Solids Suspended, - -	52·5	42·7	...
Solids Dissolved, - -	32·2	39·2	...
Solids (Total), - - -	84·7	81·9	...

TABLE VIII.—TEN SAMPLES OF CRUDE SEWAGE TAKEN DURING THE NIGHT FROM 9 P.M. ON 28TH OCTOBER TO 7 A.M. ON 29TH OCTOBER, 1900.

Results of Analyses stated as grains per gallon.

Sample No.	Chlorides.	Oxygen Consumed.	Hour Taken.
1	2·6	1·5	9—10 p.m.
2	2·9	2·1	10—11 „
3	2·1	1·3	11—12 midnight
4	1·2	1·1	12—1 a.m.
5	1·5	1·2	1—2 „
6	1·4	1·3	2—3 „
7	1·5	1·4	3—4 „
8	1·5	1·4	4—5 „
9	1·6	1·7	5—6 „
10	2·3	2·0	6—7 „
Average, - -	1·8	1·5	

TABLE IX.—TWENTY-FOUR AVERAGE HOURLY SAMPLES OF CRUDE SEWAGE AND TANK EFFLUENT, TAKEN BETWEEN 9 P.M. ON THE 19TH AND 9 P.M. ON THE 20TH NOVEMBER, 1900.

Results of Analyses stated as grains per gallon.

Sample No.	Crude Sewage.		Tank Effluent.		Hour Taken.
	Chlorides.	Oxygen Consumed.	Chlorides.	Oxygen Consumed.	
1	2·6	1·7	+ 3·2	+ 2·2	9—10 p.m.
2	2·5	1·6	+ 2·9	+ 2·0	10—11 ,,
3	2·4	1·2	+ 2·9	+ 2·0	11—12 midnight.
4	2·1	1·0	+ 2·8	+ 2·0	12—1 a.m.
5	1·7	0·7	+ 2·6	+ 2·0	1—2 ,,
6	1·7	0·6	+ 2·2	+ 1·4	2—3 ,,
7	1·6	0·6	+ 2·2	+ 1·4	3—4 ,,
8	1·6	0·6	+ 1·9	+ 1·2	4—5 ,,
9	1·8	0·9	- 1·7	+ 1·1	5—6 ,,
10	2·2	1·1	— 1·7	- 1·0	6—7 ,,
11	2·4	1·5	— 1·9	- 1·3	7—8 ,,
12	3·0	2·8	- 2·0	- 1·8	8—9 ,,
13	3·7	2·3	- 2·5	- 1·6	9—10 ,,
14	3·6	2·8	- 2·8	- 1·8	10—11 ,,
15	3·3	2·9	- 3·2	- 2·1	11—12 noon.
16	3·7	3·0	- 3·2	- 2·3	12—1 p.m.
17	4·1	3·0	- 3·5	- 2·8	1—2 ,,
18	4·2	2·8	- 3·6	2·8	2—3 ,,
19	5·2	2·9	- 3·9	- 2·8	3—4 ,,
20	5·3	3·2	- 4·2	- 2·8	4—5 ,,
21	4·1	2·9	+ 4·4	- 2·8	5—6 ,,
22	3·4	2·3	+ 4·2	+ 2·8	6—7 ,,
23	3·2	1·8	+ 3·9	+ 2·6	7—8 ,,
24	2·9	1·8	+ 3·7	+ 2·5	8—9 ,,
Average	3·0	1·5	2·9	2·0	

2·2

TABLE X.—SAMPLES OF TANK EFFLUENT AND OF FILTER EFFLUENT, TAKEN DURING THE DAY OF 22ND NOVEMBER, 1900, COMMENCING WITH TANK EFFLUENT AT 7 A.M.

Results of Analyses stated as grains per gallon.

Sample No.	Tank Effluent.		Filter Effluent.		Percentage Purification.	Filter Effluent Nitrates.	Filter No.
	Chlorides.	Oxygen Consumed.	Chlorides.	Oxygen Consumed.			
1	4·5	2·5	4·0	1·1	56	·4	2
2	3·8	1·9	3·4	1·1	42	·3	3
3	3·4	1·8	3·4	0·8	55	·5	4
4	3·6	1·9	3·3	0·9	53	·4	5
5	3·6	2·2	3·4	0·8	63	·6	1
6	3·8	2·8	3·7	1·1	61	·4	2
7	4·0	2·7	3·8	1·2	55	·2	3
8	4·2	2·8	3·8	1·3	53	·4	4
9	4·3	2·8	4·0	1·5	46	·3	5
10	4·3	2·8	3·9	1·3	53	·5	1
Average	3·9	2·4	3·6	1·1	53	·4	

TABLE XI.—AVERAGE SAMPLES OF EFFLUENTS PREPARED FROM THE ABOVE FOR MORE COMPLETE ANALYSIS; ALSO AVERAGE SAMPLE OF SEWAGE.

	Sewage.	Tank Effluent.	Filter Effluent.
Chlorides, - - - -	4·1	3·9	3·7
Oxygen Consumed, - -	2·6	2·2	1·0
Free Ammonia, - - -	1·88	1·31	0·87
Albuminoid Ammonia, -	0·28	0·35	0·19
Nitrites, - - - -	Present.	...	Abundant.
Nitrates, - - - -	...	0·02	0·4
Solids (Total), - - -	79	64	...
Solids (after settling), -	35	29	...

Table XII.—Work done by Filters.

23rd October, 1900, 7 A.M. to 5 P.M.

Filter No.	Time occupied in Filling, Standing Full, and Emptying.					
	Filling.		Full.		Emptying.	
	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.
1	1	45	1	...	...	35
2	1	45	...	55	...	35
3	1	25	...	50	...	40
4	1	15	...	50	...	40
5	1	10	...	45	...	40
1	1	18	...	50	...	30
Averages,	1	26	...	52	...	37

22nd November, 1900, 7 A.M. to 7 P.M.

Filter No.	Time occupied in Filling, Standing Full, and Emptying.					
	Filling.		Full.		Emptying.	
	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.
2	...	55	1	35	...	35
3	1	5	1	30	...	35
4	1	...	1	30	...	35
5	1	...	1	30	...	35
1	1	15	1	15	...	35
2	1	5	1	...	...	40
3	1	...	1	...	...	35
4	...	55	1	5	...	35
5	1	...	1	...	...	35
1	1	10	...	40	...	35
Averages,	1	5	1	12	...	35

Amount of Effluent from Tank passed into Filters on 22nd November, 1900.

	Filter No. 1. Clinker.	Filter No. 2. Coke.	Filter No. 3. Coke.	Filter No. 4. Coal.	Filter No. 5. Coal.
First Filling, - - -	5,563	4,706	4,756	4,169	4,606
Second Filling, - - -	5,119	4,756	4,388	4,025	4,388
Total, - - -	10,682	9,462	9,144	8,194	8,994
	Gallons.				

APPENDIX.

"Document No. I."

Crude Sewage.—Estimation of Solids in Suspension by Sedimentation.

23rd October, 1901.—The first four samples of sewage collected hourly in winchester quart bottles were used for this purpose, and the method of procedure was as follows:—

Two large glass vessels, each of a capacity equal to a winchester and of a conical shape, were used for settling the sewage. The diameter of the base was about nine inches and of the extremity about one inch. The narrow end was connected by means of a rubber tube to a graduated measure of similar calibre, and a clamp placed between the two vessels. The first two samples of sewage were put into these bottles, and allowed to stand for two hours. By this time the greater portion of the visible solids had subsided, and were either lying at the neck of the vessel or adhering to the sides, which were gently brushed down with a twig. The clamp was now eased, and the solids allowed to flow into the graduated measure. After a few minutes the clamp was again tightened, and the sewage returned to the winchester. This was repeated, and thus each of the four samples was deprived of all the solids that would settle during a period of two hours. The samples, on being removed to the laboratory, were again placed in the special glass vessels, for further sedimentation during a period of sixteen hours. The solids thus obtained were first measured as to volume, and then dried and weighed. The results were:—Four samples of sewage, Nos. 1 to 4, having a total capacity of 10,800 cubic centimeters, yielded, after two hours' settling, 33 c.c. of sludge, which, when dried at 100 deg. F., weighed 0.986 grams.

The same, after sixteen hours' further settling, yielded 12 c.c sludge, which, when dried, weighed 0.298 grams. Adding the results of the two settlings, we obtain as total sludge 45 c.c., and weight when dried 1.284 grams; that is, 1.284 grams of dried solids in 10,800 c.c. of sewage, equal to about 12 grams in 100,000 c.c., or 8.4 grains in a gallon.

It must be remembered that this estimation of solids by sedimentation only represents the heavier particles, and that a great portion of the suspended solids in fresh sewage does not readily settle.

An estimation was made of the total solids in a sample of sewage and of tank effluent taken on the afternoon of the same day, when the sewage was somewhat stronger. Of crude sewage 300 c.c. was passed through filter paper. All the suspended solids caught in the filter, when dried at 100 deg. F. and weighed, were found to be in the proportion of 52.5 grains per gallon. Of the liquid that passed through the filter paper 150 c.c. was evaporated to dryness, and thus the amount of solids in solution was ascertained to be in the proportion of 32.2 grains per gallon. By adding those two estimations we find the total solids amount to 84.7 grains per gallon.

Similarly, the total solids in a corresponding sample of tank effluent was weighed. The results were:—Suspended solids, 42.7; dissolved solids, 39.2; total solids, 81.9.

"Document No. II.'

Methods of Sampling.

Crude Sewage.—As the quality and volume of sewage varies greatly during the course of a day and from day to day (see Diagrams 1 to 5), it becomes exceedingly important in obtaining samples to adopt some proper method of sampling. The plan followed was to take a sample at the measuring well every fifteen minutes. These samples were put into a pail, and at the end of the hour the whole was stirred up and a winchester quart filled. This was called an average hourly sample. To obtain an average sample for the whole period of sampling, a quantity was taken in proportion to the flow from each average hourly sample.

Tank Effluent.—The sampling of tank effluent was carried out in the same manner as the sewage, and at the same time, when the tank effluent was to be compared with the sewage. But when it was desirable that the samples of tank effluent should correspond with the samples of filtrate, the sampling was continued every fifteen minutes the whole time a filter was filling; then the number of samples varied with the length of time a filter was in filling, but generally there were more than four in every average sample.

Filter Effluent.—The sampling of filter effluent was found to be a somewhat difficult matter, as during the discharge of the filters the rate of flow varied considerably. As will be seen from Table XII., the whole time occupied in emptying a filter varied from thirty to forty minutes, and might be divided into three stages. At first there was a great rush when the valve was opened, which continued until the water level in the well had reached the top of the outlet pipe; then followed a period when the flow was fairly steady, until the well was empty and the flow had reached its minimum. After that drainage of the filter began and the flow went on dribbling. The necessity for obtaining an average sample lies in the fact that the drainage or minimal flow was generally of a superior character to the first rush of filter effluent. In taking samples, however, an effort was made to take quantities of the liquid in proportion to the flow. For that purpose as many as twenty small samples would be taken during the emptying of one filter to make up an average sample of filter effluent.

I have discussed in the report the conditions under which one liquid may be compared with another in drawing conclusions as to the purification effected upon the sewage in its passage through the works.

"Document No. III."

Methods of Examining Samples.

Two methods of examination are generally followed—the *Physical* and the *Chemical.*

Physical.—By using one's senses, a great deal may be learned of the character of sewage and sewage effluents. Standing at a sewer outfall, we see a foul liquid carrying a number of ever varying heterogeneous particles of effete matter, but we cannot see into its depths. If we put some

into a glass vessel and allow it to stand, the grosser particles soon subside, forming a *deposit* variable in quantity, while the liquid may or may not become clear and *transparent*. A simple method of measuring transparency is to place some printed matter at the side of the sample bottle, and see whether, on looking through the liquid, the type is visible and readable. Domestic sewage has generally a greyish *colour* and a variable but distinctive *odour*, whereas, when mixed with trade refuse, these characters vary according to the nature of the refuse, which may thus be detected, or at least suspected.

Chemical.—The methods of sewage analyses are by no means uniform; therefore, the results are frequently not comparable. For example, some analysts, after allowing the sample to stand for some time, use only the supernatant liquid, others pass the liquid through a coarse filter paper (London), while others shake up the sample before analysing it (Manchester). In all our analyses, except the first series, supernatant liquid was used. As sewage is of very unstable composition, and rapidly undergoes changes in warm weather, the length of time that elapses between the taking of the samples and carrying out the analysis affects the results. The results will vary according to the method, which should always be stated. Without going into details, one may say that sewage analyses are generally made on the lines laid down for potable water, and the terms used may be briefly explained.

Chlorides represent for the most part common salt, and exist in rain water to a limited extent. In the samples of rainfall collected at Bothwell I have found the amount to vary from 0.3 to 0.5 grains per gallon. In pure upland waters the amount never exceeds 1 grain per gallon. As common salt is largely used for culinary purposes and exists in large quantity in urine, domestic sewage contains from 2 to 10 grains per gallon. Thus the amount of chlorides present in a given sample gives some indication of the strength of the sewage.

Oxygen Consumed or Moist Combustion.—As all organic substances are more or less liable to oxidation (*i.e.*, to combine with oxygen), and as organic matter in domestic sewage is the main cause of pollution, some measure of the amount of organic matter may be obtained by determining the amount of oxidation that takes place in samples of sewage under certain conditions. These conditions need not be described, but the method employed is known as the four hours' moist combustion test at 80 deg. F. The amount of oxygen absorbed in this test by potable waters examined varies from .01 to .35 grains per gallon, whereas, in sewage the amount absorbed varies from 1.0 to 5.0 grains per gallon. By some trade effluents, such as spent liquor from ammonia chemical works, the amount of oxygen absorbed varies from 50 to over 100 grains per gallon.

Ammonia.—Free or saline ammonia is abundant in sewage and most sewage effluents, but the amount present cannot be taken as a measure of the degree of impurity.

By oxidising the nitrogenous organic matter in water or sewage, ammonia is obtained, and has been termed organic or albuminoid ammonia. The amount obtained is considered an important and reliable measure of the impurities in potable waters, but its value in sewage analysis has been questioned.

Nitrates are seldom found in crude sewage, and, when present in sewage effluents, are an indication that satisfactory purification has and is taking place.

"Document No. IV."

Standards of Purity for Sewage and Trade Effluents.

Many attempts have been made to lay down standards of purity, based upon physical or chemical or biological results, to which all effluents should conform. Experience in the administration of the Rivers Pollution Prevention Acts in this County clearly shows that it would be unwise at present to fix standards of purity, but some of those which have been laid down by different authorities might be quoted.

The Rivers Pollution Commission, in their Fourth Report, dated 29th June, 1872, lay down the following standards of purity (page 104) based upon their "experience acquired by the incessant investigation for four years of the chief manufacturing processes carried on in this country:—

"*(a)* Any liquid containing, *in suspension*, more than three parts by weight of dry mineral matter, or one part by weight of dry organic matter in 100,000 parts by weight of the liquid.

"*(b)* Any liquid containing, *in solution*, more than two parts by weight of organic carbon, or .3 part by weight of organic nitrogen in 100,000 parts by weight.

"*(c)* Any liquid which shall exhibit, by daylight, a distinct colour, when a stratum of it, one inch deep, is placed in a white porcelain or earthenware vessel."

Recommendations *(d)*, *(e)*, *(f)*, *(g)*, *(h)*, *(i)*, *(k)* I have omitted.

The Clyde Purification Commissioner, Sir John Hawkshaw, in his Report, dated 21st March, 1876, refers on page xxvi. to the evidence of Mr. Crookes, an eminent chemist, who suggests a more simple test for the purity of the effiuent water, in the following terms:—"I think it would be better to take such a test as it does not require a chemist to see. If a water is clear to the eye, has no offensive taste or smell, does not deposit a sediment on standing, and will allow fish to live and thrive in it, it is certainly good enough to go into a river, whether it contains much or little carbon or nitrogen." (Minutes of evidence, page 57.)

The Joint Committee administering the Rivers Pollution Prevention Acts applicable to the rivers Mersey and Irwell, have fixed the following standard:—The limit of oxidisable impurity allowed is such as will absorb 1 grain of oxygen per gallon of sample in four hours, or 0.1 grain of albuminoid ammonia per gallon.

"Document No. V."

Standard Requirements in the Construction of Sewage Works.

In England the Local Government Board exercise, in various ways, control over expenditure upon public works when the money is to be raised by loan. If, therefore, a local authority desires to provide sewage purification works in that manner, the plans and proposals require to be submitted to the Board for their approval. The Board have found it necessary to lay down from time to time standards of requirements or rules for the guidance of local authorities in preparing plans for their approval. At present I understand that, owing to the recent develop-

ments in the method of purifying sewage, the Board have a difficulty in laying down fixed regulations, but have provisionally given the following indications :—

It is the custom to require that the storm overflows shall be so fixed as to allow only sewage flowing at a rate exceeding six times the normal flow to pass away untreated. Of the "six times" which must be treated, full treatment of the first three volumes is required, and partial treatment of the other three volumes, *i.e.*, straining through a coarse filter at the rate of 500 gallons a day of 24 hours. In the case of contact beds, the Board consider that these should never have more than three fillings a day. Thus, if the system in use is contact beds, in dry weather they would only be used once a day, while in wet weather they would get three fillings. For continuous filters the rate of flow should be about 200 gallons a day per square yard for a filter 6 feet deep. Of course, these rules are necessarily provisional only, and until the Sewage Commission have completed their labours, the means for framing proper rules will, it is feared, be somewhat scanty.

As to land, the Board consider that one acre of good porous land will deal, by irrigation, with the sewage of a population of from 200 to 300.

IV.—THE CLYDE AND ITS TRIBUTARIES AS A SOURCE OF WATER SUPPLY.

As the question of rivers pollution is intimately related to the question of water supply, I have endeavoured to ascertain the extent to which the Clyde is used as a source of supply for (*a*) *trade purposes* and (*b*) *domestic and general purposes.*

Water Supplies for Trade Purposes.—To the owners of the various public works believed to be using water direct from the Clyde and its tributaries, circulars were issued in the following terms :—

"I understand that water from the River Clyde is used at the above works for trade purposes, and, as I am collecting information for a report dealing with the prevention of pollution of streams, I would be interested to know—

"1. The approximate quantity of water, stated in gallons or cubic feet, used by you daily from this source; and

"2. Whether during this year (1901) you have had any cause for complaint on account of pollution."

The information obtained is incomplete, but, as summarised in Table K, shows that on an average about 18,000,000 gallons of water are daily abstracted direct from the Clyde and its tributaries for industrial purposes. Complaints of recent pollution were elicited in one or two cases. One firm complained that the Clyde was occasionally affected by coal-dross washings, and another complained of pollution affecting their water supply from the North Calder. I was interested to note that one firm whose works are situated at Carmyle Weir—the Carmyle Bleach Works—state in their reply, "We never had a complaint of pollution." The positions of the pumping stations or intake on the streams have been indicated on Map II. by red-coloured numbers. These show that many of the pumping stations are situated on the lower reaches of the Clyde, and quite close to, one even within, the City of Glasgow boundary.

Table K.—List of Public Works obtaining Water Supplies from the River Clyde and its Tributaries.

Public Work.	Numbers on Map, coloured red, indicating position of Intake on Streams.	Average Daily Consumpt in Gallons.
The Clyde.		
Supplied by Glasgow Corporation, ...	1	2,200,000
Shawfield Chemical Works, ...	2	187,500
Phœnix Tube Works, ...	3	34,000
Clyde Paper Mills, ...	4	980,000
Clyde-bridge Steel Works, ...	5	400,000
Clyde Iron Works, ...	6	2,000,000
Cambuslang Dye Works, ...	7	960,000
Carmyle Bleaching Works, ...	8	378,000
Hallside Steel Works, ...	9	400,000
Craighead Colliery, ...	10	25,000
Camp Collieries, ...	11	60,000
Caledonian Railway, Motherwell, ...	12	720,000
Lanarkshire Steel Works, ...	13	720,000
Wishaw Iron and Steel Works, ...	14	840,000
Carstairs Junction Station, ...	15	119,000
North Calder and Tributaries.		
Summerlee and Mossend Iron Works,	—	1,000,000
Carnbroe Iron Works, ...	16	100,000
Calderbank Steel Works, ...	17	100,000
Moffat Paper Mills, ...	18	100,000
Glengowan Print Works, ...	19	200,000
Caldercruix Paper Mills, ...	—	2,000,000
South Calder and Tributaries.		
Milnwood Iron and Steel Works, ...	20	500,000
Clydesdale Iron and Steel Works, ...	21	100,000
Globe Iron and Steel Works, ...	22	63,000
Dalzell Iron and Steel Works, ...	23	700,000
Coltness Iron Works, ...	24	360,000
Chapel Colliery, ...	25	12,000
Avon.		
Avonbank Bleach Works, ...	26	96,000
Shortcleuch.		
Lead Mines, Leadhills, ...	27	2,000,000
	Total, -	17,354,500

Notes.—(1) The bulk of the information as to consumpt was obtained by inquiry by circular letter of date 13th November, 1901, a copy of which will be found in the text of the Report; (2) the replies to this circular also show that almost all the consumers have no cause to complain of pollution of the streams; (3) the North Calder is largely used as a feeder for the Monkland Canal, which again is largely used as a source of water supply for numerous public works in Coatbridge, including Calder Iron Works; (4) there are many public works not included in the above Table drawing water supplies from head streams of tributaries of the Clyde. In some cases the water is impounded. There are also a number of collieries which draw water from various streams. These include Douglas Colliery and Eddlewood Colliery; (5) the figures given in the Table are in some cases only a very rough estimate.

Water Supplies for Domestic and General Purposes.—As these supplies are mostly owned by local authorities, a circular letter was issued to those local authorities owning water-works in the following terms :—

"In connection with a report I am preparing for the County Council, it would be of interest to obtain some information regarding the various water-works constructed, or in process of construction, in the different parts of the county. In the hope that you would give me such assistance in this matter as you are at liberty to afford, I enclose a note of one or two questions which occur to me to ask, but any other useful information would be appreciated—

"Name of water-works,.....

"Owners,.....

"Date of commencement of works, ...

"(1) The sources of water supply.

"(2) The extent of supply.

"(*a*) Capacity of reservoir.

"(*b*) The average daily flow or consumpt of water in area served.

"(3) Regarding the character or quality of the water.

"(*a*) Copy of any analyses made.

"(*b*) Whether filtered."

The information obtained is very incomplete, but what has been received is summarised in Table L. On Map II. the positions of the various water-works have been indicated by dark shading, and the drainage areas of these water works by light shading. All these, with one exception, are situated on the head streams of important tributaries of the River Clyde, the exception being the Bathgate and District Water-works, situated on the head streams of the Forrest Burn, which flows through Linlithgow into the Avon. The information submitted shows that during recent years there has been an enormous increase in the extent and number of water-works throughout the county, due to the great increase of population in the Middle Ward area of the county. The increased impounding of water from the head streams of important tributaries of the Clyde will, by lessening the volume of water flowing in these streams, tend during summer weather to increase the polluting effect of the increased discharges lower down.

The water-works are all situated in the Middle and Upper Wards of the county; those owned by Burgh Authorities are ten in number. The water-works owned by the Middle

Ward District Committee are seven in number, and have a storage capacity of 578,850,000 gallons, the average daily consumpt being about 6,417,000 gallons. The works owned by the Upper Ward District Committee are mostly connected with springs, whereas in the Lower Ward District the supplies are obtained through the Corporation of Glasgow from Loch Katrine. From the report of Sir John Hawkshaw, the commissioner appointed in December, 1874, to inquire as to the purification of the River Clyde, we learn that the town of Motherwell at that date obtained a water supply from the River Clyde through the Caledonian Railway Company, who had a pumping station on the Clyde near that town. Since then the Burgh of Motherwell, like all other populous places in the county, has obtained a supply from upland sources.

The result of these inquiries might be summed up thus—(1) There is a large volume of water taken direct from the Clyde and its tributaries by manufacturers even in the lower reaches of the river, and there is little serious complaint of pollution. (2) There has been an increased abstraction of water from the head streams of Clyde tributaries. This impounding will diminish the flow of pure water in the stream during summer weather, and correspondingly increase the flow of polluted liquid. (3) There is not at any part of the Clyde or its tributaries a water supply obtained for potable or domestic purposes that can be considered liable to pollution.

Rainfall.

In connection with the sampling of streams and reporting the effect of pollutions, it is very necessary to have records of rainfall and of the flow of water in the streams. No records of the flow have yet been made. Two meteorological stations have, however, been established since 1899—one at Bothwell, and the other at Leadhills. The records of rainfall at these stations for the years 1900 to 1902 are here shown in two diagrams. There have also been extracted some records of the rainfall at various stations situated in other parts of the county, many of which are connected with water-works. These are given in order, according to the amount of rainfall registered, in Table M at page 134. It will be seen that the amount varies chiefly according to the height above sea level.

The first four stations have an elevation not exceeding 200 feet O.D., and the average annual rainfall does not exceed 30 inches. Most of the stations have an elevation between 200 and 700 feet, and at these the average annual rainfall varies between 30 and 45 inches. At the highest stations, such as Leadhills and Dunside Water-works, the average annual rainfall is about 60 inches.

DIAGRAM shewing the Weekly Rainfall recorded at Bothwell (Altitude, O.D., 153), and at Leadhills (Altitude, O.D., 1,300).

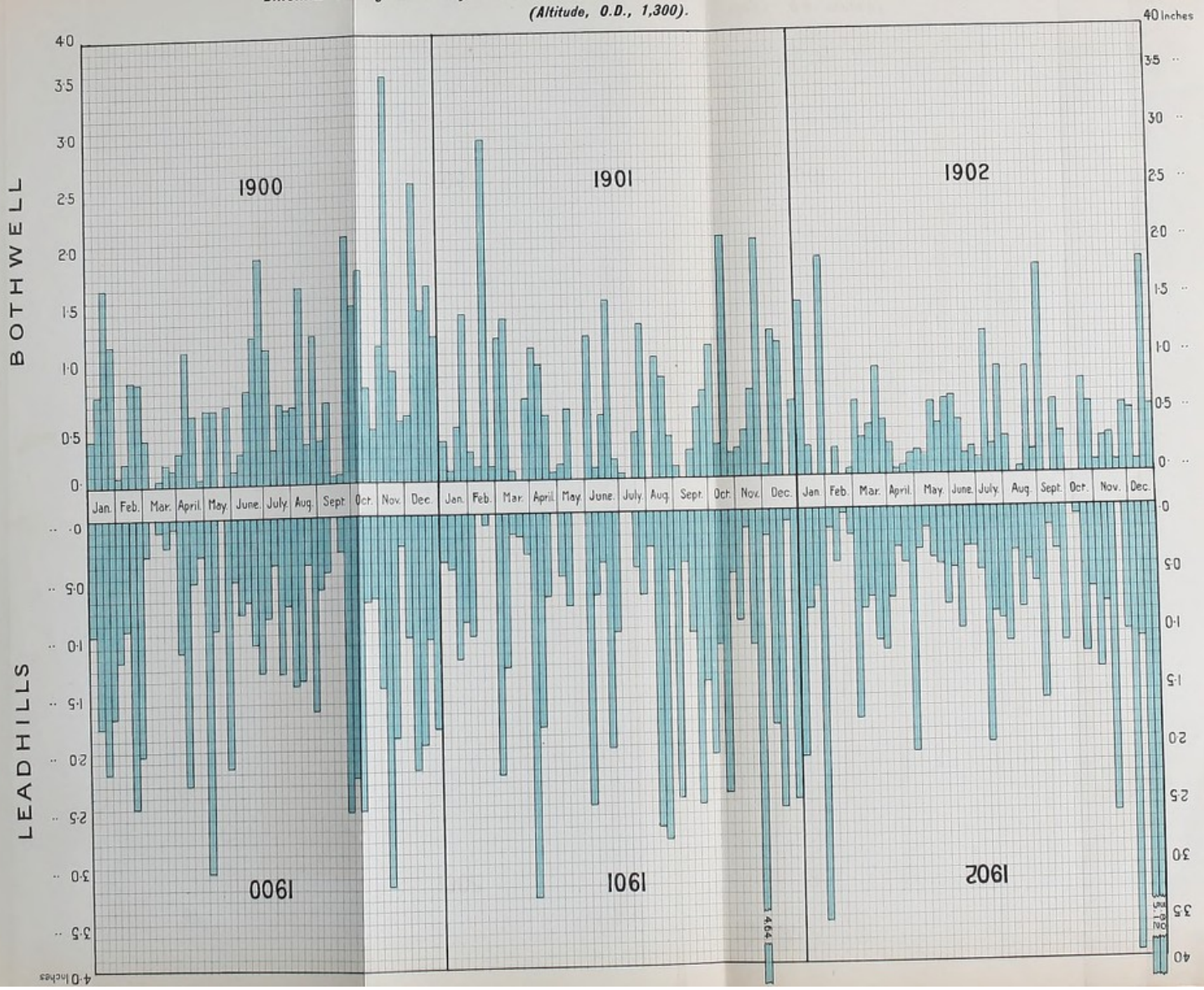


DIAGRAM shewing the Monthly Rainfall, in inches, recorded at Bothwell (Altitude, O.D., 153), and at Leadhills (Altitude, O.D., 1,300).

The PINK shading represents the Rainfall at Leadhills, and the GREEN shading the Rainfall at Bothwell.

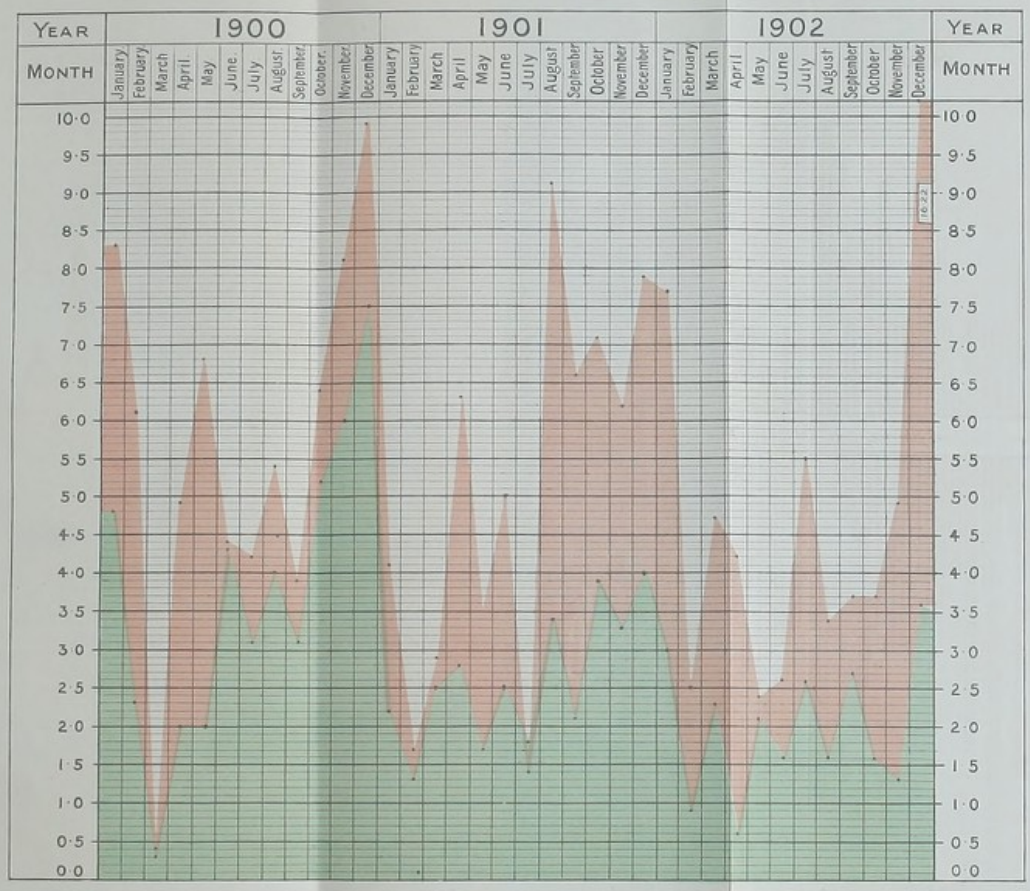


Table L.—Public Water Supplies.

(1) Water-works owned by Burgh Local Authorities.

Burgh.	Population (Census, 1901).	Source of Supply and situation of Works.	Storage Capacity.	Average daily Consumpt.
			Gallons.	Gallons.
Airdrie, ...	22,288	*Old Works.*—Roughrigg Reservoir and Shotts Burn, Shotts Parish.	No information.	No information.
Coatbridge and District,	36,991 11,126	* *New Works.*—Head streams of Culter Water, in Lamington Parish. Two reservoirs above Cowgill.		
Motherwell, ...	30,418	*Old Works.*—One of the head streams of Abbey Burn and Mouse Water, Carluke Parish. Reservoir situated near Springfield.	No information.	No information.
		* *New Works.*—Head streams of Culter Water in Culter Parish. Reservoir thereat.		
Hamilton, ...	32,775	*Old Works.*—Earnock, Cadzow, and other Burns, Hamilton Parish.	167,193,185	1,750,000
		* *New Works.*—Kype Water and streams, southern boundary of Avondale Parish.	142,000,000	
Wishaw, ...	20,873	*Old Works.*—Bowridge Burn, Gair Burn, and springs, Carluke Parish.	No information.	No information.
		* *New Works.*—The Potrail, Potrenick, and Peden head streams of the Clyde, Crawford Parish. Reservoir on Peden Burn.		
Lanark, ...	6,567	Springs at Tinto, ...	17,000,000	250,000
Biggar, ...	1,366	King's Beck Stream, Parish of Culter.	28,125	237,600

* *Water-works* recently completed, or in course of construction.

TABLE L.—PUBLIC WATER SUPPLIES—*Continued.*

(2) MIDDLE WARD DISTRICT.

The whole area was formed into a Special District for Water Supply purposes by the Middle Ward Water Act, 1892. The population of the District at the Census of 1901 was 179,363.

Water-works.	Source of Supply.	Situation of Supply.	Storage Capacity.	Average daily Consumpt.
			Gallons.	Gallons.
* Glengavel, ...	Glengavel Water, Powbrone Burn, and others.	Southern boundary of Avondale Parish.	250,000,000	2,000,000
Bothwell, Dunside,	Lochfennoch Burn and Logan Water.	South-western boundary of Lesmahagow Parish.	75,700,000	1,250,000
* Bothwell, Logan,	Logan Water.	South-western boundary of Lesmahagow Parish.	186,000,000	2,000,000
Blantyre, ...	Lees Burn.	North-east of East Kilbride Parish.	7,600,000	460,000
Cambuslang, ...	Cocks Burn and Kirk Burn.	Cambuslang Town.	54,000,000	550,000
Harthill, ...	Lint Mill Burn.	North-east of Shotts Parish.	5,550,000	100,000
Newmains, ...	Springs at Dura.	About centre of Cambusnethan Parish.	...	57,000
		Totals, -	578,850,000	6,417,000

* *Water-works* recently completed, or in course of construction.

Table L.—Public Water Supplies—*Continued.*

(3) Upper Ward District.

Water Supply District.		Water Supply District.	
Name.	Population, 1901.	Name.	Population, 1901.
Carluke, ...	4,740	Kirkfieldbank, ...	1,027
Law, ...	1,269	* Thankerton, ...	200
* Braidwood, ...	587	Douglas, ...	1,206
Carnwath and Carstairs Junction, ...	1,679	* Roberton, ...	200
* Blackwood, ...	877	Crawford, ...	350
Lesmahagow, ...	1,732		

* *Water Districts* recently formed.

Notes.—(1) In the above districts the source of supply is in every instance from springs. (2) The following localities in the Upper Ward have public supplies provided by private owners:—Auchenheath, &c. (population, 642); Auchengray (population, 80); Tarbrax (population, 880); Elsrickle (population, 115); Ponfeigh (population, 750); Leadhills (population, 835).

(4) Lower Ward District.

Water Supply District.		Source of Supply and Situation.	Average daily Consumpt.
Name.	Population, 1901.		
Shettleston, Tollcross, &c.,	23,970	Supply from Glasgow Water-works Reservoirs at Lethamhill and Garthamlock.	Not known.
Bishopbriggs, ...	1,138		
South Lenzie, ...	955		
North Cadder, ...	1,825		
South Cadder, ...	5,810		
Rutherglen, ...	4,820		

TABLE M.—RAINFALL IN INCHES AS RECORDED AT STATIONS IN THE COUNTY OF LANARK, ARRANGED IN FIVE DECENNIAL PERIODS (FROM THE YEAR 1850 TO 1899), FOR WHICH THE ***Average*** ANNUAL RAINFALL IS GIVEN; ALSO THE ***Actual*** RAINFALL FOR EACH OF THE YEARS 1900, 1901, 1902.

NAME OF STATION.	Number on Map (coloured black).	POSITION.	Approximate Elevation O.D., in feet.	DECENNIAL PERIODS ENDING										ANNUAL PERIODS.		
				1859.		1869.		1879.		1889.		1899.				
				Years.	Rainfall.	Years.	Rainfall.	Years.	Rainfall.	Years.	Rainfall.	Years.	Rainfall.	1900.	1901.	1902.
Bothwell Castle, ...	6	Near Bothwell, ...	160	'50-'59	27	'60-'69	29	'70-'79	31	'80-'89	25	'90-'99	29	43·1	28·7	22·6
Bothwell—Hay Lodge,	7	Bothwell, ...	160	...	...	...	...	...	...	...	...	...	...	45·1	31·9	24·2
Auchenraith House, ...	8	Near Hamilton, ...	160	'54-'59	28	'60-'69	31	'70-'76	32	...	...	...	...	...	...	...
Dalzell House, ...	11	,, Motherwell, ...	180	...	...	...	...	'72-'79	31	'80-'89	26	'90-'99	31	40·4	29·3	23·5
Cambus-Wallace, ...	16	,, Biggar, ...	760	...	...	...	...	'72-'79	32	'80-'89	29	'90-'99	31	...	...	...
Cambuslang, ...	5	,, Cambuslang, ...	400	...	...	...	...	...	...	'80-'89	31	...	...	36·2	30·6	21·0
Roughrigg Reservoir,	9	,, Airdrie, ...	770	...	...	...	...	...	...	'84-'89	28	'90-'99	35	42·3	...	...
Lanark, Khyber Lodge,	15	Lanark, ...	700	...	...	'66-'69	34	'70-'79	33	'80-'84	33	'93-'95	31	39·0	25·7	...
Hamilton Water Works,	10	Near Hamilton, ...	600	...	...	...	...	...	...	'80-'89	32	'90-'99	35	44·9	32·7	26·7
Glasgow—Belvidere,	2	Glasgow, East, ...	100	...	...	...	...	...	...	...	...	...	...	44·8	33·7	27·9
,, Queen's Park,	3	,, South Side,	200	...	...	...	...	'77-'79	35	'80-'89	33	'90-'99	36	46·2	34·6	30·8
,, Observatory,	1	,, University,	180	'57-'59	41	'60-'69	44	'70-'79	43	'80-'89	35	'90-'98	37	46·9	32·9	29·1
Mauldslie Castle, ...	12	Near Dalserf, ...	380	...	...	...	...	...	...	...	...	'98-'99	35	46·9	31·8	24·8
Cleghorn House, ...	14	,, Lanark, ...	720	...	...	...	...	...	...	...	...	'92-'99	37	49·0	35·6	27·0
Hillend Reservoir, ...	4	,, Caldercruix, ...	640	...	...	'60-'69	33	'70-'79	37	'80-'89	35	'90-'99	38	44·9	32·1	26·9
Wiston, ...	20	Wiston, ...	800	...	...	...	...	'70-'79	42	'80-'89	42	...	...	....	...	...
Glasford, ...	13	Glasford, ...	800	...	...	...	...	...	...	...	...	'98-'99	40	49·0	33·2	27·6
Douglas Castle, ...	19	Douglas, ...	740	...	...	'61-'69	51	'70-'79	43	'80-'89	44	'90-'94	51	...	...	...
Glengavel, ...	17	Avondale Parish, ...	870	...	...	...	...	...	...	. .	...	'98-'99	51	47·8	39·0	32·3
Dunside, ...	18	Lesmahagow Parish,	1050	...	...	...	...	...	...	...	...	'98-'99	62	68·3	51·5	47·3
Leadhills, ...	21	Leadhills, ...	1300	...	...	...	...	...	...	...	...	...	...	69·3	62·3	62·9

NOTES.—(1) As few of the records are complete for all the decennial periods, the actual years to which the average applies are given. (2) The names of the stations are arranged according to the amount of rainfall recorded—thus, the lowest is placed first and the highest last in the Table. (3) Most of the information was obtained from the Annual Reports of the Scottish Meteorological Society. (4) There is also a station on the Pedden Burn, near Elvanfoot, in Crawford Parish, in connection with the Wishaw Water Works, at which the rainfall for the year from October, 1901, was 56·1 inches.

V.—THE CLYDE AND ITS TRIBUTARIES AS AFFECTED BY POLLUTION.

A description of the basin of the Clyde given in the fourth Report of the Royal Commission on the Pollution of Rivers, published in 1872, is in the following terms :—

"The Clyde, which is laden with so much filth before it joins the sea, is, in its upper reaches, and for more than two-thirds its course, one of the most beautiful of Scottish rivers, watering the pleasantest of upland pastoral valleys, traversing rich and fertile lowland landscapes, falling through abrupt and rocky wooded defiles, and furnishing, in one portion of its course, some of the finest river scenery in the island. Nowhere is there a greater contrast than that which exists between the unpolluted waters which come down to Lanark, or even as far as Hamilton, and the foul and stinking flood to which they have been changed not twenty miles beyond that point. In this short interval, the river has received the Cadzow Burn, which brings in the drainage of the town of Hamilton; the comparatively clean South Calder, which, however, brings down the drainage of a considerable population in and around Wishaw and Motherwell; the North Calder, draining the thickly-populated districts of Airdrie and Coatbridge; the Kelvin, contributing the liquid refuse of Kirkintilloch and of the manufactories near it; the Cart, fouled by Johnstone, Barrhead, Pollokshaws, and Paisley; and the drainage of the large manufacturing city of Glasgow. Within the space of a few miles the subject of river pollution is thus exhibited in almost all its forms, and may be witnessed in every degree of intensity. * * * It is, however, to the City of Glasgow itself that the principal pollution of the Clyde is due."

This description of the Clyde is in large measure applicable at the present day, but requires amplification. The information now submitted relates to the Lanarkshire Clyde or Clydesdale. The river may be considered in four divisions—(1) from the head streams of the Clyde to Lanark; (2) thence to Hamilton; (3) thence to Carmyle; (4) thence to the county boundary below the City of Glasgow. The condition of the Clyde as affected by pollution in these divisions may be discussed from two aspects. First, there is the amount and character of the pollutions received within a certain stretch of the river, and, second, the effect produced, as ascertained by sampling and analyses. Reference should be made to Map I. for *trade pollutions*, to Map II. for *sewage pollutions*, and to Table W in the Appendix.

Sources of Pollution.

(1) From the junction of the two head streams of the Clyde down to the Burgh of Lanark the river covers a distance of 40

miles, and is practically free from pollution. Although there are a number of villages draining into the Clyde and its tributaries, the only special drainage districts within this area are Douglas, Carnwath, and Crosslaw—total population, 2,950. The industries liable to cause pollution are lead mining at Leadhills, Tarbrax Shale Oil Works, Caledonian Oil Refining Works, and three coal-dross washers at Coalburn. These works are all situated on tributaries.

(2) From Lanark to the Hamilton and Motherwell Bridge the river covers a distance of 15 miles, and receives the drainage of the Burgh of Lanark, the Burgh of Wishaw, and one of the outfalls from the Burgh of Motherwell—total population about 37,576. There are also a number of villages along the Clyde side, but the special drainage districts within this area are Lesmahagow, Carluke, Law, Netherton, Strathaven, Stonehouse, and Larkhall—total population about 28,920. They are all situated on tributaries, and are long distances apart. The sources of industrial pollution are eighteen in number—fifteen coal-washers, two ammonia works, and one bleach work.

(3) From Hamilton Bridge, below the junction of the Avon, to Carmyle Weir, the Clyde traverses a distance of 9 miles, and is very liable to pollution. The only burgh draining directly into the river is Hamilton, but Motherwell drains into it by the South Calder, and Airdrie and Coatbridge by the North Calder—total population, 112,336. The special drainage districts draining direct to the Clyde are Bothwell, Blantyre, Uddingston, Aitkenhead & Tannochside, and Newton & Flemington. Indirectly through the North Calder are the districts of Bellshill, Holytown, New Stevenston, Chapelhall, and Baillieston, and through the South Calder, Cleland and Omoa—total population about 53,465. The industrial sources of pollution are fifty-one in number, and are various in character.

Notwithstanding the liability to pollution in this division, it is astonishing to find the Clyde at Carmyle Weir, even during dry weather, still comparatively pure.

(4) From Carmyle Weir to the county boundary below Govan the Clyde travels a distance of 11 miles, which might be sub-divided thus:—From Carmyle to Rutherglen Bridge, 4¼ miles; through the city and adjacent burghs of Partick, Kinning Park, and Govan, 6¼ miles; and beyond, to the county boundary on the south side of the river, half-a-mile.

Within the first-mentioned sub-division there are three special drainage districts, viz.:—Cambuslang, Mount Vernon, and Shettleston

& Tollcross — total population, about 38,060. The industrial sources of pollution are thirteen in number, mostly situated on the south side of the river, and quite near to the city boundary.

The following extract from a letter received in March of this year (1903) from the secretary of one of the city angling clubs is of interest when considering the condition of this stretch of the river:—

"Within the last 10 years pollution has become very marked from various sources. The sewage from Shettleston and Tollcross on the north side, Cambuslang and Eastfield on the south, and also from Wardlawhill, Rutherglen; the ammonia liquid from Clyde Iron Works, and coal washings from various pits from Tollcross up to Newton.

"No fish are to be got at Dalmarnock Bridge now. It used to be a famous place for large trout, but these have reached the vanishing point. Only two trout were caught last year, a little above Westthorn Waterworks, where not so long ago they were fairly plentiful. A few fine trout are still to be had a little below Cambuslang and above Bogleshole Ford; grayling used to be very plentiful opposite Dalbeth and below Cambuslang, but they have not been seen at these places for years. Trout can accommodate themselves to sewage, but not grayling. There is, however, no great inducement to fish for trout among floating filth."

The only stretch of the Clyde so seriously polluted as to give rise to offensive conditions is that portion which flows through the City of Glasgow and adjacent burghs, with a total population of 912,033 at the census of 1901. This immense population, with its varied industries, discharges all liquid refuse into the river and harbour within such a short distance as to cause the natural agencies which make for purification in running streams to be so overpowered that offensive conditions result.

Similar conditions are to be found in many of the small streams within the county, but not in the Clyde itself above Glasgow. Even North Calder Water, although grossly polluted by sewage from the Burghs of Airdrie and Coatbridge, is at its outfall to the Clyde so much purified that samples taken from the river at Carmyle Weir show that pollution, when estimated by chemical analyses, has in great measure disappeared.

The Effect of Pollution as ascertained by Sampling and Analyses.—The collection of samples from the River Clyde for chemical analyses on an extensive scale seems to have been first carried out in 1884 at the instance of the City Authorities. The results of these analyses are contained in a paper read by Mr. R. R. Tatlock, one of the City Analysts, at the congress of the Sanitary Association held at Glasgow in August, 1894. Altogether fifty-six samples

were then collected, commencing with the Avon Water near its junction with the Clyde at Hamilton Bridge. These samples seemed to be taken with the distinct object of showing the nature and extent of the pollutions entering the Clyde and its tributaries between the above point and the city boundary. The natural purification taking place in the river is also to some extent brought out by four samples taken at Hamilton Bridge, Bothwell Bridge, Uddingston, and Clyde Paper Mills. The analyses of these four samples are not strictly comparable, as they were not all taken on the same day, but they clearly show that comparatively little depreciation in the quality of the water was detected, notwithstanding the many pollutions affecting the river between the points of sampling. In Mr. Tatlock's paper there are some curious observations as to what becomes of the suspended solid matter as found in the samples analysed, but these observations need not be here discussed.

Twice during the year 1901, and twice during the year 1902, samples were taken at various points of the Clyde and of its more important tributaries, by the inspectors and other assistants, for the purpose of forming some opinion as to the condition of the river. These samples were, as far as possible, all taken on the same day and in succession, from above downwards, so that they would be comparable with one another. The results of analyses are contained in Tables P, Q, R, S, and T. The labour involved in the sampling and analyses was very considerable, and the results are instructive in many ways, but it will not be necessary to give a detailed report. To see a series of some thirty samples of water taken on the same day from various points of the Clyde and its tributaries, all arranged in topical order, is interesting and instructive, but it is somewhat difficult to appreciate the chemical evidence furnished by analyses without seeing the samples themselves, especially polluted samples.

First Division.—The Clyde and all its tributaries in the upper reaches are beautifully clear streams, free from any evidence of pollution. The Douglas and Duneaton waters have, during heavy rainfall, the rich brown colour of peaty waters, and give in the results of analyses high figures for oxygen absorbed. These remarks apply also to the Nethan and the Avon—two tributaries in the second division.

Second Division.—The samples taken in this stretch of the river show but slight evidence of pollution, but at certain point where pollution is liable to occur, as, for example, below the Wishaw outfalls and the Motherwell outfall, no samples were taken in these series.

Third and Fourth Divisions.—If reference be made to Maps I. and II. for the position of all sources of pollution, and to the figures in the various tables under "free ammonia" and "albuminoid ammonia," evidence will be obtained of the effect of pollutions upon the river and of the natural purification which takes place. In Table P, of the samples taken during the 25th and 26th September, 1902, there are eight from the lower reaches of the Clyde, commencing with Hamilton Bridge and ending at Linthouse Ferry, just beyond the city boundary. The free and albuminoid ammonias in these eight samples are given in the following Table N. The figures in the last column show that from Hamilton Bridge to Blantyre Bridge the pollution increases. This is largely due to pollutions from the Burgh of Hamilton. There is a decline at Haughhead Bridge, but below that the North Calder enters, carrying with it the pollutions from the Burghs of Airdrie and Coatbridge. The effect of these pollutions is seen even at Carmyle Weir by the increase in the ammonias. From Rutherglen Bridge onward to Linthouse the effect of pollution is very great.

TABLE N.—SAMPLES TAKEN AT DIFFERENT POINTS ON THE CLYDE.—*See also Table P.*

No.	Points on the Clyde.	Ammonia expressed as parts per 100,000.		Total Nitrogen of Ammonias expressed as parts per 100,000.
		Free.	Albuminoid.	
14	Hamilton Bridge, - -	·011	·010	·017
18	Bothwell ,, - -	·019	·013	·026
19	Blantyre ,, - -	·029	·013	·035
20	Haughead ,, - -	·005	·016	·017
25	Carmyle Weir, - - -	·051	·011	·051
27	Rutherglen Bridge, - -	·184	·024	·171
28	Broomielaw Ferry, - -	·352	·060	·339
29	Linthouse ,, - -	·82	·02	·692

Table T contains the analyses of a series of eight samples taken on 6th October, 1902, on the lower reaches of the Clyde, from Carmyle Weir down to Whiteinch. The ammonias are given in the following Table O. The slight increase at Clyde Iron Works is due to pollution from Cambuslang. There is a slight decrease at Dalmarnock Bridge, there being little sewage pollution between these two points. There is an increase at Rutherglen Bridge, and a decrease above the weir at Glasgow Green. From that point onward the increase is very great.

TABLE O.—SAMPLES TAKEN AT DIFFERENT POINTS ON THE CLYDE.—*See also Table T.*

No.	Points on the Clyde.	Ammonia expressed as parts per 100,000.		Total Nitrogen of Ammonias expressed as parts per 100,000.
		Free.	Albuminoid.	
1	Below Carmyle Weir, - -	·001	·008	·008
2	Clyde Iron Works, - -	·005	·007	·010
3	Dalmarnock Bridge, - -	·001	·007	·007
4	Rutherglen ,, - -	·073	·016	·073
5	Above Weir at Glasgow Green,	·025	·012	·031
6	Broomielaw, just below Jamaica Bridge, - -	·120	·016	·111
7	Kelvinhaugh, - - -	·222	·040	·216
8	Whiteinch, - - - -	·492	·042	·440

Comparing the results of analyses of the samples taken on these two occasions, it will be seen that the figures for 6th October are lower than those for 26th September, yet there was no rainfall between these dates.

Table S contains a series of three samples also taken on 6th October in connection with the outfall from Dalmarnock Sewage Works. The increase in the ammonias below the sewage works outfall is very considerable, and distinctly shows the polluting effect of the effluent from these works. The high figures for oxygen absorbed are probably due, in part, to the presence of iron in the sewage works effluent.

TABLE P.—SAMPLES OF WATER TAKEN MOSTLY ON **25th and 26th September, 1902**, FROM THE RIVER CLYDE, AND FROM SOME OF ITS MORE IMPORTANT TRIBUTARIES, TABULATED IN TOPICAL ORDER, COMMENCING WITH THE UPPER REACHES.

PLACES WHERE SAMPLES TAKEN.			CHEMICAL ANALYSIS—PARTS PER 100,000.						PHYSICAL CHARACTERS.		
No.	The Clyde.	Tributaries at their Outfalls.	Chlorine.	Free or Saline Ammonia.	Albuminoid Ammonia.	Oxygen absorbed in 4 hours at 80° F.	Dissolved Solids.	Hardness (degrees Clark's Scale).	Colour (Loch Katrine = 2; Avon Water = 20).	Turbidity.	Transparency.
1	(Head Stream),	Daer Water,	0·6	·002	·009	0·38	5·	2·5	6	None	Very good
1a	Elvanfoot Bridge,	... ...	0·6	·002	·007	0·30	7·	3·2	5	Do.	Do.
1b	... ...	Elvan Water,	0·7	·002	·001	0·01	8·	3·6	1	Do.	Do.
2	... ...	Midlock Water,	0·8	·005	·003	0·12	7·	4·3	2	Do.	Very good
3	... ...	Camps Water,	0·8	·002	·003	0·11	10·	3·7	1	Do.	Do.
3a	... ...	Glengonnar Water,	1·1	·004	·001	0·02	13·	4·2	1	Do.	Do.
4	... ...	Duneaton Water,	0·8	·002	·001	0·13	8·	5·9	2	Do.	Do.
4a	... ...	Culter Water,	0·9	·001	·002	0·05	6·	3·4	1	Do.	Do.
5	... ...	Medwyn,	1·2	·003	·006	0·13	28·	9·8	3	None	Very good
6	Lampits Ferry, near Carstairs,	... ...	0·8	·003	·012	0·77	10·	4·1	9	Do.	Do.
7	... ...	Douglas Water,	0·9	·004	·019	1·16	18·	5·9	15	Do.	Do.
8	Lanark Bridge, Kirkfieldbank,	... ...	0·8	·009	·011	0·42	8·	4·7	6	Very slight	Good
9	... ...	Mouse Water,	1·2	·002	·013	0·41	26·	9·8	8	None	Very good
10	... ...	Nethan,	1·0	·005	·018	0·91	18·	7·0	14	Do.	Do.
11	Garrion Bridge,	... ...	0·8	·003	·009	0·33	10·	4·5	5	Do.	Do.
12	... ...	Garrion Burn,	1·8	·003	·002	0·07	47·	13·4	2	Do.	Do.
14	Railway Bridge (Hamilton-Motherwell),	... ...	1·0	·011	·010	0·33	14·	5·9	5	Very slight	Good
15	... ...	Avon Water,	1·1	·012	·025	1·36	15·	5·5	20	Slight	Do.
17	... ...	South Calder Water,	2·0	·002	·017	0·39	45·	14·8	7	Do.	Do.
18	Bothwell Bridge,	... ...	1·0	·019	·013	0·52	15·	5·8	8	None	Very good
19	Blantyre Suspension Bridge,	... ...	1·1	·029	·013	0·56	14·	6·1	8	Do.	Do.
20	Haughead B'dge,	... ...	1·1	·005	·016	0·54	13·	5·9	8	Do.	Do.
21	... ...	North Calder Water,	3·5	·349	·033	0·77	57·	13·8	19	Much	Almost opaque
23	... ...	Rotten Calder,	1·4	·035	·018	0·66	27·	8·8	10	Slight	Good
25	Carmyle Weir,	... ...	1·5	·051	·011	0·50	24·	7·5	9	Do.	Fair
27	Rutherglen Bridge,	... ...	4·0	·184	·024	0·54	28·	8·5	9	Do.	Do.
28	Broomielaw Ferry,	... ...	3·6	·352	·060	0·73	28·	9·4	9	Much	Opaque
29	Linthouse Ferry,	... ...	13·6	·82	·02	0·73	43·	10·4	10	Do.	Do.

NOTES.—*Nitrates.*—All the samples were examined for nitrates. The estimations were made with indigo carmine, and the results, stated as NO_3 in parts per 100,000, were as follows:—Sample, No. 5, = 0·36; No. 17, = 0·80; No. 20, = 0·18; No. 21, = 1·60; No. 23, = 1·60; No. 25, = 2·30; No. 27, = 2·38; No. 28, = 5·14; No. 29, = 6·56. After the samples had stood for about eight days all the nitrates disappeared.

Nitrites.—All the samples were examined for nitrites. The results, stated as NO_2 in parts per 100,000, were as follows:—Sample No. 3a, = ·006; No. 21, = ·75; No. 27, = ·006; Nos. 11 and 14, a small quantity; No. 17, a trace; Nos. 18 and 19, a large quantity; No. 20, a trace; Nos. 23 and 25, a medium quantity. After the samples had stood for about eight days all the nitrites disappeared.

Suspended Solids.—The amount of suspended solids in the first twenty samples was less than *one* part per 100,000. In the remaining samples the results were as follows:—No. 21, = 2·5; No. 23, = 0·92; No. 25, = 1·3; No. 27, = 2·4; No. 28, = 3·2; No. 29, = 5·5 parts per 100,000.

Odour.—Most of the samples were odourless. No. 21 had a slight odour, No. 28 had a distinct odour, and No. 29 a very distinct odour of sewage.

TABLE Q.—SAMPLES OF WATER TAKEN MOSTLY ON **10th July, 1901**, FROM THE RIVER CLYDE, AND FROM SOME OF ITS MORE IMPORTANT TRIBUTARIES, TABULATED IN TOPICAL ORDER, COMMENCING WITH THE UPPER REACHES.

PLACES WHERE SAMPLES TAKEN.			CHEMICAL ANALYSIS—PARTS PER 100,000.						PHYSICAL CHARACTERS.
No.	The Clyde.	Tributaries at their outfalls.	Chlorine.	Free or Saline Ammonia.	Albuminoid Ammonia.	Oxygen absorb'd in 4 hours at 80° F.	Dissolved Solids.	Hardness. Degrees	
1	(Head Stream),	Daer Water,	1·00	·000	·010	·092	1·0	3·5	Colourless, clear, no deposit.
2	... ...	Midlock Water,	0·90	·000	·007	·056	7·0	3·7	Do. do.
3	... ...	Camps Water,	2·50	·005	·013	·070	...	4·5	Do. do.
4	... ...	Duneaton Water,	1·10	·000	·010	·320	11·0	3·5	Clear, slight deposit.
5	... ...	Medwyn,	1·10	·006	·016	·260	22·8	6·8	Slightly turbid, small deposit.
6	Lampits Ferry, near Carstairs,	... ...	1·00	·000	·016	·250	10·0	5·5	Do. do.
7	... ...	Douglas Water,	1·30	·002	·013	·172	25·0	5·3	Clear, small deposit, no odour.
8	Lanark Bridge, Kirkfieldbank,	... ...	1·30	·006	·027	·290	10·8	3·8	Clear, small deposit.
9	... ...	Mouse Water,	1·30	·002	·032	·405	20·0	9·8	Slightly opaque and small deposit.
10	... ...	Nethan,	1·60	·003	·013	·200	28·5	9·9	Do. do.
11	Above Garrion Burn,	... ...	1·10	·001	·010	·220	14·3	5·1	Do. do.
12	... ...	Garrion Burn,	1·40	·004	·007	·140	38·5	9·8	Do. do.
13	Below Garrion Burn,	... ...	1·20	·003	·009	·250	12·8	6·4	Do. do.
14	Above Muckle Burn,	... ...	1·40	·003	·013	·300	12·0	5·5	Clear and small deposit.
15	... ...	Avon Water,	1·60	003	·030	·510	18·0	5·5	Do. do.
16	... ...	Cadzow Burn,	14·10	·400	·350	·640	92·0	9·7	Opaque, offensive odour, black deposit, and scum on surface.
17	... ...	South Calder,	2·70	·004	·040	2·850	20·0	6·8	Opaque and slight deposit, odour like coal gas.
18	Below Park Burn,	... ...	1·90	·011	·054	·440	18·0	5·9	Almost clear, small deposit, coal gas odour.
19	Below Blantyre,	... ...	1·80	·056	·024	·450	12·0	6·0	Clear, small deposit, and no odour.
20	Below Uddingston,	... ...	1·85	·052	·012	·410	11·0	5·6	Do. do.
21	... ...	North Calder,	4·80	·140	·092	1·700	68·0	8·3	Slightly yellow, small deposit, and faint odour.
22	Below North Calder,	... ...	2·70	·190	·038	·680	35·0	7·5	Opaque, slight deposit, and faint odour.
23	... ...	Rotten Calder,	3·45	·048	·027	·670	28·0	9·1	Almost clear, slight deposit, and sewage odour.
24	Below Rotten Calder,	... ...	2·00	·096	·030	·490	34·0	6·1	Almost clear, slight deposit, and faint odour.
25	Carmyle Weir,	... ...	1·90	·031	·015	·450	25·0	10·3	Clear, no deposit, no odour.
26	Below Bogleshole Ford, Cambuslang,	... ...	...	·003	·017	·327	13·3	...	Good colour.

TABLE R.—SAMPLES OF WATER TAKEN ON **18th January, 1901**, FROM THE RIVER CLYDE AND FROM SOME OF ITS MORE IMPORTANT TRIBUTARIES, TABULATED IN TOPICAL ORDER, COMMENCING WITH THE UPPER REACHES.

PLACES WHERE SAMPLES TAKEN.			CHEMICAL ANALYSIS—PARTS PER 100,000.						PHYSICAL CHARACTERS.
No.	The Clyde.	Tributaries at their outfalls.	Chlorine.	Free or Saline Ammonia.	Albuminoid Ammonia.	Oxygen absorb'd in 4 hours at 80° F.	Total Solids.	Hardness. Degrees	
6	Lampits Ferry, near Carstairs,	... ...	0·86	·005	·008	·22	20·0	3·7	Slightly turbid, small deposit.
8	Kirkfieldbank,	... ...	1·00	·005	·008	·23	17·1	3·2	Clear, small deposit.
9	... ...	Mouse Water,	1·10	...	...	·50	...	...	Slightly opaque, small deposit.
10	... ...	Nethan,	1·30	...	...	·42	...	...	Do., do.
11	Above Garrion Burn,	... ...	1·00	·007	·008	·25	16·0	5·0	Do., do.
13	Below Garrion Burn,	... ...	1·10	·007	·010	·26	26·0	8·0	Do., do.
14	Above Muckle Burn,	... ...	1·00	·006	·012	·26	18·6	5·0	Clear and small deposit.
15	... ...	Avon Water,	1·30	...	...	·48	...	...	Do. do.
16	... ...	Cadzow Burn,	2·80	...	...	1·93	...	...	
17	... ...	South Calder,	1·80	...	...	0·49	...	...	
18	Below Park Burn,	... ...	1·60	·067	·031	·32	28·4	5·8	
19	Below Blantyre,	... ...	1·10	·019	·016	·27	21·4	4·5	
24	Below North Calder,	... ...	1·70	·057	·019	·34	30·0	8·5	
25	Carmyle Weir,	... ...	1·40	·028	·014	·30	27·1	7·0	

TABLE S.—SAMPLES OF WATER TAKEN ON THE **6th October, 1902**, FROM THE RIVER CLYDE AT DALMARNOCK SEWAGE WORKS.

No.	Locality.	PHYSICAL CHARACTERS.		CHEMICAL ANALYSIS—PARTS PER 100,000.					
		After Shaking.	After Standing.	Chlorides as Cl.	Free or Saline Ammonia.	Albuminoid Ammonia.	Oxygen absorb'd in 4 hours at 80° F.	SOLIDS. Dissolved.	SOLIDS. Suspended.
1	Above Sewage outfall,	Slightly turbid, quite transparent, no odour,	Clear and transparent, slight yellowish colour, medium brownish flocculent deposit,	2·5	·001	·011	0·34	27·	1·7
2	At Sewage Works outfall,	Very turbid, quite opaque, objectionable odour,	Clear and transparent, yellowish colour, large brownish flocculent deposit,	19·4	2·40	·20	1·89	81·	4·9
3	Below Sewage Works outfall,	Rather turbid, fairly transparent, no odour,	Clear and transparent, slight yellowish colour, large brownish flocculent deposit,	12·6	·700	·025	0·38	37·	2·3

NOTE.—Samples Nos. 2 and 3 contained iron both in solution and suspension. The amount in the sample taken at the sewage outfall was very considerable.
Sample No. 1 contained nitrites to the extent of ·016 parts per 100,000, estimated as NO_2.

TABLE T.—SAMPLES OF WATER TAKEN ON THE **6th October, 1902**, FROM THE LOWER REACHES OF THE RIVER CLYDE, TABULATED IN TOPICAL ORDER.

No.	Locality.	Physical Characters.		Chemical Analysis—Parts per 100,000.						Hardness (degrees Clark's Scale).
		After Shaking.	After Standing.	Chlorides as Cl.	Free or Saline Ammonia.	Albuminoid Ammonia.	Oxygen absorb'd in 4 hours at 80° F.	Solids. Dissolved.	Solids. Suspended.	
1	Below Carmyle Weir,	Clear and transparent, no odour,	Clear and transparent, slight yellowish colour, trace of dark granular deposit,	1·8	·001	·008	·30	26·	0·	8·5
2	C.R. Bridge, Clyde Ironworks,	Clear and transparent, no odour,	Clear and transparent, slight yellowish colour, trace of dark granular deposit,	1·9	·005	·007	·25	...	0·	...
3	Dalmarnock Bridge,	Very slightly turbid, quite transparent, no odour,	Clear and transparent, slight yellowish colour, small brownish deposit, chiefly flocculent,	2·0	·001	·007	·27	28·	0·	8·9
4	Rutherglen Bridge,	Slightly turbid, transparent, no odour,	Clear and transparent, slight yellowish colour, medium dark flocculent deposit,	5·2	·073	·016	·32	43·	3·52	9·6
5	Above Weir at Glasgow Green,	Slightly turbid, transparent, no odour,	Clear and transparent, slight yellowish colour, medium dark brown flocculent deposit,	3·0	·025	·012	·38	28·	1·28	9·7
6	Broomielaw, just below Jamaica Bridge,	Rather turbid, fairly transparent, type just readable, very slight odour,	Clear and transparent, slight yellowish colour, large brownish deposit, partly granular and partly flocculent,	4·4	·120	·016	·31	34·	4·0	9·7
7	Kelvinhaugh, just below entrances to Queen's and Prince's Docks,	Rather turbid, fairly transparent, slight odour,	Slightly turbid, but transparent, slight yellowish colour, large brownish flocculent deposit,	24·0	·222	·040	·62	70·	4·7	10·8
8	Whiteinch,	Turbid, type just readable, slight odour,	Clear and transparent, slight yellowish colour, large brownish flocculent deposit,	76·0	·492	·042	·47	173·	4·0	11·5

NOTE.—Nitrites stated as NO_2 in parts per 100,000 were present, as follows:—Sample No. 1, = ·016; No. 2, = ·026; No. 3, = ·026; No. 4, = ·020; No. 5, = ·17; No. 6, = ·012.

Table U.—Analyses showing the Extent of Pollution of North Calder Water at different points in its course to the Clyde.

Samples taken 2nd and 3rd October, 1902.

Locality.	Physical Characters.		Chemical Analysis—Parts per 100,000.							
	As Sampled.	After Standing.	Chlorides as Cl.	Nitrites and Nitrates.	Ammonia.			Oxygen absorbed in 4 hours at 80° F.	Solids.	
					Free.	Alb.	Total.		Diss.	Susp.
North Calder, above junction of Luggie Burn,	Very slightly turbid, quite transparent, no odour,	Clear and transparent, slight yellowish brown colour, very small deposit,	3·7	NO_2 present. NO_3 nil.	·007	·016	·023	·51	87·	1·0
Luggie Burn, near junction with North Calder,	Very turbid, opaque slight, sewage odour,	Transparent, very slightly opalescent, yellowish brown colour, large black flocculent deposit,	5·0	NO_2 nil. NO_3 nil.	1·17	·095	1·265	2·65	52·	8·6
North Calder, at Ellismuir,	Rather turbid, transparent, no odour,	Clear and transparent, yellowish brown colour, medium brownish flocculent deposit,	4·8	NO_2 = ·50 NO_3 = ·40	·254	·027	·381	1·14	69·	2·1
North Calder, at outfall to Clyde,	Do.	Do.	4·3	NO_2 nil. NO_3 = 1·0	·103	·024	·127	·80	69·	2·8

Note.—The Nitrates were estimated by Indigo Carmine.

VI.—EFFORTS AT PURIFICATION OF THE CLYDE—HISTORICAL NARRATIVE.

The pollution of the Clyde by Glasgow sewage seems to have exercised the mind of the Glasgow Authorities for over half-a-century. The complete history, therefore, of the efforts made to prevent or mitigate pollution would be very instructive to present-day administrators. Such, however, is not readily available; but from an interesting paper on the "Main Drainage of Glasgow" by Mr. A. B. M'Donald, C.E., City Engineer, I have obtained much of the following information:—

In 1851, when the population of Glasgow was only 330,000, it appeared that the state of the river was such as to bring forth a proposal to construct a great reservoir in the Upper Ward of Lanark to discharge artificial spates, during the droughts of summer, to scour the sewage of the harbour of Glasgow, and the lower reaches of the river, out to sea.

In 1858 the Sanitary Committee of Glasgow asked a report from Professor Anderson, of Glasgow, and Mr. Bateman, of London, on the best means of deodorising the sewage of the city, with observations on the probability of recovering part of the cost by the sale of the deposit as a manure. The general conclusions of this report recommended the use of a deodoriser to "sweeten" the contents of the sewage. The reporters, however, were of opinion that the problem did not admit of an economic solution.

In 1867 a joint-committee representing the various public bodies interested in the Clyde was appointed, and in 1868 obtained a report from two eminent engineers of London recommending a scheme for intercepting the sewage of the city at three different levels, and, after pumping, conveying it in a conduit to the Ayrshire coast.

In 1868 a Royal Commission was appointed for the purpose of enquiring "how far the present use of rivers or running waters in England for carrying off the sewage of towns and populous places, and the refuse arising from industrial processes and manufactures, can be prevented without risk to the public health, or serious injury to such processes and manufactures, and how far such sewage and refuse can be utilized and got rid of otherwise than by discharge into rivers or running waters, or rendered harmless before reaching them; and also for the purpose of inquiring into the effect on the drainage of lands and inhabited places of obstructions to the natural flow of

rivers or streams caused by mills, weirs, locks, and other navigation works, and into the best means of remedying any evils thence arising."

In 1869 an extension of the reference was made authorising the Commissioners "to visit the River Tweed and its tributaries, and the River Clyde and its affluents, in that part of our United Kingdom called Scotland, and also to visit such other rivers, or part of rivers in that part of our said Kingdom as we may from time to time be pleased to direct, by signifying our pleasure, under the hand of one of our Principal Secretaries of State."

In 1872 was issued the fourth report of the Commissioners, dealing with the pollution of rivers in Scotland. In it a description of the Clyde basin is given, with an account of (1) Pollution by town sewage, and (2) Pollution by manufacturing refuse. The description and analyses of samples show that the Clyde was not seriously polluted above the City of Glasgow, and was practically free from pollution above Hamilton. No evidence was obtained of any injury to health that could be attributed to the polluted condition of the river, although it was offensive to the inhabitants of Glasgow residing near the river. One of the conclusions and recommendations pointed out the necessity for defining what is meant by "noxious or polluting water," and endeavouring to do so by fixing standards of purity.

In 1873 (18th October) the fifth report of the Commissioners, which deals with mining and metal manufacturing pollutions throughout Great Britain, was issued. Lanarkshire is not specially referred to, with the exception of the mines at Leadhills, which affect the Elvan, which, however, was found to be free from any evidence of pollution before it reached the Clyde.

In 1874 (15th December) a Commission was issued for the purpose of enquiring as to what towns and places contributed to the pollution of the River Clyde and its tributaries, and how and by what means the sewage of such towns and places, and the refuse arising from industrial processes and manufactures carried on within the same can be utilized or got rid of without risk to the public health, or serious injury to such processes and manufactures, otherwise than by discharge into the River Clyde and its tributaries, or rendered harmless before reaching them; and also for the purpose of enquiring into the best means of otherwise securing the purification of the said river and its tributaries, and of remedying any evils or inconveniences arising from its present polluted state.

The report of the Commissioner, Sir John Hawkshaw, is dated 21st March, 1876, and recommends that for Glasgow and its neigh-

bourhood (including Airdrie and Coatbridge) it would not be wise to adopt a system of deodorisation, and to discharge the effluent water into the Clyde at Whiteinch, but that it would be better to convey the sewage still further, to an outfall in the River or Firth of Clyde, or in the sea; that for Wishaw, Motherwell, and neighbouring places south of Airdrie and Coatbridge the whole of the sewage of the district should be disposed of locally on the land. For the Burgh of Hamilton he suggested that the sewage would be best disposed of by some deodorising process, expensive though it may be; and that for the upper region of the Clyde, where Lanark is the only town of importance, the sewage could be distributed over land in the neighbourhood. Some interesting observations and recommendations as to statutory powers for the prevention of pollution are made under the headings "General Remarks" and "Suggested General Provisions."

Consequent on this report, the Town Council of Glasgow gave notice of their intention to promote a Clyde Conservancy Bill, but this met with much opposition, and the Bill was withdrawn.

In 1876 (15th August) the Rivers Pollution Prevention Act, making further provision for the prevention of the pollution of rivers, and in particular to prevent the establishment of new sources of pollution, received the sanction of Parliament. This Statute is applicable to Great Britain, and is still the general authority under which action is taken. There has been but one amending Act of an explanatory nature, dated 27th July, 1893.

Mr. Charles P. Hogg, C.E., in a discussion on Mr. M'Donald's paper on the "Main Drainage of Glasgow," said that, being interested in the subject for many years, he had followed the historical summary given by Mr. M'Donald with great interest, but that there were two or three omissions which he would like to mention, so as to have on record the following schemes which had not been referred to in the paper:—

In 1876 the Glasgow Town Council appointed a deputation to visit all the chief towns in England where sewage was being treated, and in the following year a most valuable report was presented, in which it was recommended that the sewage should be treated by the process of precipitation and filtration.

In 1878, Mr. Bateman, C.E., submitted a report to the Town Council, suggesting three alternative schemes for the interception and disposal of sewage. The first was to take all the sewage to Dalmuir by pumping the sewage of the south side across the river. The second was to take all the sewage down to Shiels, near Braehead, not far from Renfrew, which involved the pumping of the north

sewage over to the south side. The third scheme was to take the sewage of the north side of the city down to Dalmuir, and the sewage of the south side to Shiels, near Braehead.

In 1880 a deputation of the Town Council visited various places, and afterwards recommended that all the sewage should be taken to Dalmuir. About this time the Town Council bought the property at Dalmuir—about 200 acres—at a cost of about £100,000.

In 1884 a valuable pamphlet was published by the late G. W. Muir, pointing out that it was a mistake to concentrate the whole of the sewage of Glasgow at one particular place, and that it ought to be dealt with in districts. He suggested a good many districts—perhaps too many—but to Mr. Muir belonged the credit of having been the first to point out the suitability of the site at Dalmarnock for sewage works, and the first instalment of the Glasgow Sewage Works was established there.

In 1887 a Bill was promoted for what is now "The Caledonian Underground Railway." The Town Council opposed the Bill, until an agreement was concluded whereby the Railway Company undertook to sustain the whole expense of re-arranging the affected drainage of the city as the Corporation should deem most fitting. This led ultimately to the construction of the Dalmarnock Sewage Works, which were completed in the year 1894, and have since been working so satisfactorily that the Corporation have agreed to adopt similar purification works for the rest of the city.

In 1896 the Glasgow Corporation Sewage Act was passed, and provides for the interception and conveyance of the sewage of the remaining portion of the city and adjacent areas on the north side of the river to Dalmuir, where purification works are being erected.

In 1898 another Glasgow Corporation Sewage Act was passed, authorising the interception of all the sewage of the city and adjacent areas on the south side of the river, and its conveyance to Braehead for treatment.

In Sir John Hawkshaw's report of 1876, reference is made to two reports not included in the foregoing historical narrative. These are (1) Report by Professor Anderson in relation to the sewage of Glasgow —October, 1869; and (2) Report, designs, and estimate for the drainage of the sewage of Glasgow and the purification of the River Clyde, by George Thornton, C.E.—1869.

In continuation of the above narrative, reference might be made to

(I.) The Royal Commission appointed in 1898 to inquire and report—first, what method or methods of treating and disposing of sewage (including any liquid from any factory or manufacturing process) may properly be adopted, consistently with due regard for the requirements of the existing law for the protection of public health, and for the economical and efficient discharge of the duties of local authorities; and, if more than one method may be so adopted, by what rules, in relation to the nature or volume of sewage, or the population to be served, or other varying circumstances or requirements, should the particular method of treatment and disposal to be adopted be determined; and, secondly, to make any recommendations which may be deemed desirable with reference to the treatment and disposal of sewage.

This Commission issued an Interim Report on 12th July, 1901, Minutes of Evidence and a Second Report in 1902, and a Third Report during the current year.

(II.) The Royal Commission on Salmon Fisheries was appointed in 1900, and their report issued in 1902. This report contains, under the headings "Pollution" and "Volume of Water in Rivers," much interesting information, some of which is here quoted:—

INFLUENCE OF RIVER POLLUTION ON FISH LIFE.

Domestic Sewage.—Ordinary domestic sewage does not contain any directly toxic substance, but when its organic matter undergoes bacterial decomposition it becomes injurious in two ways:—

(1) By actively taking up oxygen in the process of decomposition, and thus deoxygenating the water of the river.

(2) By yielding toxic substances as a result of decomposition.

(*1*) *Deoxygenating the Water of the River.*—Under ordinary conditions river water contains something like 6 c.cm. per litre of dissolved oxygen; but, as a result of the decomposition of organic matter, this may be used up faster than the water can take it from the air, and thus the dissolved oxygen may partially or entirely disappear from the water. Information is required as to the extent to which water may be deprived of oxygen without endangering the life of fish. The experiments which have been already conducted have been of too short a duration, and are insufficient in number. But the series of observations made by Dr. Noel Paton, so far as they go, confirm the conclusion enunciated by Messrs. Dibdin and

Thudichum, that water with less than 3 c.c. of oxygen per litre must be considered injurious to salmonoids.

(2) *Development of Toxic Substances.* — Of the substances developed in the putrefaction of sewage, hydrogen sulphide appears to be the most injurious to fish. Substances poisonous to fish may also be added to sewage as disinfectants or deodorisers. Among these are chloride of lime and carbolic acid.

Effluent from Manufactories.—When the effluents from manufactories contain large amounts of organic matters, as is the case in the untreated effluents from breweries, distilleries, paper works, and tanneries, &c., they act like sewage in depriving the water of oxygen. But many manufactories discharge substances which are directly toxic. Among these are the chlorine from bleaching works, paper works, &c., the acids from steel works and tin-plating works, the alkalis from wool washings, the gas lime, cyanides, and carbolic acid from gas-works, and the organic acid in the pot ale of distilleries. A number of witnesses have spoken to the consequent danger of occasional or accidental poisoning of salmon, and among instances which might be quoted is a case in the Forth, when 400 dead fish were taken out; and it is stated that, in the Doon, on five several occasions during the last thirty years, fish were poisoned.

Effluents from Mines.—The fine detritus of coal washings may act as an irritant to the gills of the fish, and, by forming a deposit on the river bed, prevents the free passage of oxygen to the ova. From certain old mines containing iron pyrites an acid water is discharged which is very toxic to fish.

* * * * * * * * *

The extent to which the Rivers of England, Scotland, and Wales are injuriously influenced by Pollution.—Some other rivers, however, are rendered "practically useless for fishing" by more special causes. We may instance the Rhymney, where, on account of the coal washing from the various collieries, the bed "is in a filthy state: it is perfectly black, and, after the floods, instead of what there used to be—sand—you may see all along the beach nothing but coal dust." It should be added that these injurious deposits are not always carried from the mines or works by the effluent water. Cases were mentioned to us where quantities of the refuse of large works, such as slag, are carted to the banks of the river and tipped out in such positions as to be almost certainly carried away by the next flood or freshet. The law as it stands prohibits the putting solid matters into streams, and we think there ought to be some restriction on the

placing of such matters on the banks in a manner that, whether wilfully or not, results in an evasion of this prohibition.

* * * * * * * * *

State of Law as regards Pollution of Rivers.

Under the existing Salmon Fishery Acts it is necessary to prove that the pollution complained of has poisoned or killed fish in England, or has poisoned, or been deleterious to salmon, to an extent injurious to any salmon fishery in Scotland, or has poisoned or killed any salmon or smolt in the Tweed, but it is by no means easy to establish a sufficient case, and, further, under the English and Scotch General Acts, no person is liable if he prove to the satisfaction of the Court that he has used the best practicable means, within a reasonable cost, to render the pollution harmless.

We are of opinion that Section 13, Salmon Fisheries (Scotland) Act, 1862, should be amended by striking out the words "to an extent injurious to any salmon fishery," and think it desirable that Section 5, Salmon Fishery (England) Act, 1861, should be made to conform with Scottish Section so amended.

But, in considering this subject, it is necessary to distinguish between non-tidal and tidal waters.

Non-tidal Waters.—In non-tidal waters, apart from the Salmon Fishery Acts, the law with reference to pollution by sewage and trade refuse and other forms of pollution is already strong, and, if it was enforced, Local Fishery Boards might have little cause for complaint. But there are difficulties in the way of enforcing the law, arising particularly from the following:—

(*a*) County Councils and other local authorities are not infrequently themselves responsible for the nuisance, and cannot be induced to take action.

(*b*) In many cases watersheds are under the jurisdiction of several authorities, and if one of these authorities neglects to enforce the law, it can be pleaded that the work of the others would be to a large extent rendered nugatory.

(*c*) Schemes for the disposal of sewage are often expensive, and local authorities are inclined to welcome a plausible excuse for postponement. When considerations such as those under (*b*) and (*c*) influence the action of local authorities they can only be expected to weigh also with the owners of works from which pollutions pass into the streams. As will appear hereafter, so soon as the necessity of purification is insisted upon it is not impracticable to secure their co-operation. — *Report of the Commissioners on Salmon Fisheries — V. Pollution, pages 42-45 — Constituents of Sewers and other Polluting Effluents.*

Another View of River Pollution.

Perhaps, as one to whom angling is the solitary illusion left—the one pursuit which, for me, age cannot wither nor custom stale its infinite variety—I shall be suspected of prejudice when I affirm that, of all saddening, maddening objects in nature, none is so bad as a defiled river. It is never so offensive as at the present season, when the wealth of vegetation is at its height, and life is at its best and most abundant everywhere, down to the very verge of the poisonous flood. It is the old story of *corruptio optimi;* just as there is no more lovable, irresistibly-attractive object in the landscape than a clear-running river, so there is none so hideously distressing than a polluted one. Grass may be grimy, trees cankered and smirched, yet these renew their brief verdure every spring, and for a while make brave show in the sunlight, but there is no kindly season for the poisoned stream. Month after month it rolls its inky flood, showing tainted foam in the rapids and greasy scum in the deeps; no dancing ephemerids haunt its sullen wave, no waterfowl its reedless banks; its never-ending office is to bear an obscene freight of drowning puppies and cats, evil rags, and (unloveliest flotsam of civilisation) torn newspapers.—"*Memoirs of the Months*"—*Sir Herbert Maxwell.*

From other sources quotations are here given as to the Influence of River Pollution on Health:—

"In the Clyde basin Lanark and Hamilton have no complaint to make. From Kirkintilloch we learn that the condition of the stream is a source of great discomfort, but not of ill-health. Dr. John Steele, the Medical Officer of Pollokshaws, describes it as a long town, crossed by the River Cart, which stinks offensively, but he declares that the inhabitants occupying houses near to the river are just as healthy as those who live far away from it." . . . "The Medical Officer of Glasgow, reporting an annual death-rate of 30·6 per 1,000 in that city—speaking, too, with a knowledge, not only of the circumstances of his own town, but of the circumstances relating to this subject which all the other towns of Scotland furnish—says:—'It is difficult to prove any influence of the river on the death-rate, but its polluted state is to a considerable extent a source of discomfort, and, very probably, in some cases, of ill-health.'" . . . "It is such conditions as these (density of population), and not the neighbourhood of the filthy Clyde that makes Glasgow an unhealthy town. Dr. William Gairdner, the Medical Officer of the City of Glasgow, indeed informed us that the people living near the banks of the polluted river are as healthy as those who live away from it."—*Rivers Pollution Commission, 1868, Fourth Report, Part I., Pages 47 and 48.*

Visits frequently paid in the autumn to certain delightful friends, who at that season migrate from London to their estate on the western coast of Scotland, repeatedly obliged me to go by steamer down the Clyde, sometimes in July, sometimes in August, and on more occasions than one I have been compelled, during part of the passage between Glasgow and Greenock, to hold my handkerchief to my nose so as to minimise my perception of the abominable smell given off from the drainage of Glasgow poured into the river. Now all along its banks are shipyards, where thousands of men saw and hammer all day long, and had this stench been the fever-breeding agent which we are led to suppose, these men ought to have been swept away wholesale. Yet there were no statements of unusual mortality among them.—*Sanitation in Theory and Practice—Herbert Spencer—In "Facts and Comments."*

APPENDIX.

TABLE W.—SOURCES OF POLLUTION LIABLE† TO AFFECT THE

Divisions of the River Clyde.	Sewage Pollutions.			
	Burghs.	Population.	Special Drainage Districts.	Population.
Division I.—From the junction of the Daer and Potrail to Castlebank, near Lanark (40 miles).			Douglas,	1,555
			Crosslaw,	395
			Carnwath,	900
Division II.—From Lanark to the Hamilton and Motherwell Bridge (15 miles).	*Lanark,	6,567	Lesmahagow,	2,105
	*Wishaw,	20,873	Law,	1,660
	*Motherwell (say, one-third),	10,136	Carluke,	5,255
			Strathaven,	5,020
			Stonehouse,	3,260
			Larkhall,	11,000
			Netherton,	620
Division III.—From Hamilton and Motherwell Bridge to Carmyle Weir (9 miles).	Motherwell (say, two-thirds),	20,282	Cleland & Omoa,	2,055
	*Hamilton,	32,775	New Stevenston,	3,255
	Coatbridge,	36,991	Holytown,	1,825
	Airdrie,	22,288	Bellshill,	9,890
			*Bothwell,	2,860
			*Uddingston,	7,270
			*Aitkenhead & Tannochside,	3,225
			Chapelhall,	1,905
			*Newton & Flemington,	4,840
			*Blantyre,	12,755
			Baillieston,	3,585
Division IV. — From Carmyle Weir to the County Boundary at Braehead, below Govan (11 miles).	*Rutherglen,	17,220	*Cambuslang,	13,450
	*Glasgow,	761,709	*Mount Vernon,	4,015
	*Govan,	82,174	*Shettleston & Tollcross,	20,595
	*Kinning Park,	13,852	South Lenzie,	1,165
	*Partick,	54,298		

† Many of the sources do not cause pollution. * Sources of pollution which either wholly or

RIVER CLYDE, EITHER DIRECTLY* OR THROUGH ITS TRIBUTARIES.

INDUSTRIAL POLLUTIONS.					
Coal Dross Washers.		Ammonia Works.	Paper Mills.	Print, Dye, and Bleach Works.	Other Industries.
Dalquhandy. Bellfield. Auchlochan. Douglas.		Tarbrax Shale Oil Works.			Leadhills Lead Mining and Smelting Works. Caledonian Oil Refining Works.
Wilsontown. Law No. 3. Shawfield. Swinhill. Cornsilloch. Skellyton. Quarter. Bog. Merryton.	Home Farm. Allanton. Ferniegair. Ross. Wishaw Iron Works. *Broomside. Camp. Sunnyside.	Millburn Coke and Chemical Works. Wishaw Iron Works		Avonbank Bleach and Dye Works.	Clydesdale Distillery.
Eddlewood. Earnock. *North Motherwell. Chapel. *Craighead. *Bothwell Castle. Douglas Park. Parkhead. Bothwell Park. Viewpark. New Orbiston. Milnwood. Shotts Iron Works. Kepplehill. Stane. Baton. Hillhouserigg. Ladyland.	Royal George. Glen Cleland. *Priory. Bardykes. Dechmont. Gilbertfield. Hallside. Newton No. 2. Monkland No. 3. Faskine. Calder Iron Works. Linrigg. Holytown No. 2. Rosehall. Tannochside. Kirkwood. Nackerty. Ellismuir.	Coltness Iron Works. Shotts ,, ,, Calder ,, ,, Carnbroe ,, ,, Summerlee ,, ,, Gartsherrie ,, ,, Langloan ,, ,, Coatbridge Gas Works. Gas Liquor Works, Coatbridge. Uddingston and Bothwell Gas Works. Hamilton Gas Works.	Caldercruix Paper Mills. Moffat Paper Mills.	Glengowan Print Works. *Carmyle Bleach and Finishing Works.	
Gateside. Westburn. Darngavil. *Easterhill.		*Clyde Iron Works. Shettleston Oil and Chemical Works.	*Clyde Paper Mills. *Eastfield Paper Mills.	*Cambuslang Dye Works. *Clydesdale Dye Works. *Clydebank Bleach Works.	*Shawfield Chemical Works. Gartloch Distillery.

partly discharge *directly* into the River Clyde; all other sources discharge into tributaries.

TABLE X.—ANALYSES OF SAMPLES FROM GLENGOWAN PRINT WORKS TAKEN ON 5TH MARCH, 1903.

Results stated in grains per gallon.

SOURCE.	SOLIDS.			Chlorides as Cl.	Oxygen absorbed in 4 hours at 80° F.	Sulphates.	Lime.	Free Alkali as NaOH.	Free Acid as HCl.	*Colour Dilution.	PHYSICAL CHARACTERS.	
	Fixed.	Volatile.	Total.								As Sampled.	After Standing.
Bleach-house, -	18·	9·	27·	4·3	1·04	Small quantity,	Small quantity,	2·52	—	× 2	Rather turbid, just transparent, slight pinkish brown colour,	Rather turbid, just transparent, small greyish granular deposit.
Print-house, -	22·	32·	54·	5·5	2·08	,,	Very small quantity,	—	3·07	× 20	Very turbid and opaque, chocolate colour,	Turbid, not transparent, considerable reddish brown flocculent deposit.
Dye-house, -	21·	18·	39·	6·8	2·25	,,	Small quantity,	—	2·04	× 50	Very turbid and opaque, bright red colour,	Turbid and opaque, large reddish brown flocculent deposit.
At inlet to settling ponds,	20·	19·	39·	6·1	1·88	,,	,,	—	2·81	× 15	Very turbid and opaque, light chocolate colour,	Rather turbid, not transparent, large brownish flocculent deposit.
At outlet from settling ponds to North Calder,	15·	10·	25·	3·1	1·02	,,	,,	—	—	× 8	Turbid and opaque, medium brownish red colour,	Rather turbid, type just visible, medium brownish flocculent deposit.

* This column gives the approximate dilution necessary to reduce the colour to the standard suggested by the Rivers Pollution Commission in their Fourth Report, 1872.

Samples taken from streamlet conveying sewage of Baillieston Western Outfall, at different points in its course to the North Calder, and arranged in topical order, showing the changes in opacity and turbidity. The analyses are given in Appendix, Table Y.

1 2 3 4 5 6 7 8

Photo. of samples after standing 20 hours.

1 2 3 4 5 6 7 8

Photo. of samples after standing 14 days.

TABLE Y.—SAMPLES OF SEWAGE FROM BAILLIESTON WESTERN OUTFALL AND WATER-COURSE, TAKEN ON 6TH OCTOBER, 1902.

LOCALITY.	PHYSICAL CHARACTERS.	CHEMICAL ANALYSIS—PTS. PER 100,000.				
		Ammonia.			Oxygen absorbed in 4 hours at 80° F.	Suspended Solids.
		Free.	Albuminoid.	Total.		
1. At outlet from Baillieston main sewer at west end of district.	Very turbid, not transparent, very decided sewage odour. On standing there was a very large dark flocculent deposit.	3·94	0·28	4·22	3·14	15·4
2. At culvert under Caledonian Railway about 130 yards from No. 1.	Turbid, not transparent, very decided sewage odour. On standing, medium dark and white flocculent deposit.	4·08	0·26	4·34	2·13	10·2
3. In plantation at mouth of pipe, about 620 yards below No. 1.	Turbid, not transparent, slight odour. On standing, large dark and white flocculent deposit.	3·80	0·10	3·90	1·10	15·6
5. In plantation, about 923 yards below No. 1.	Slightly turbid, transparent, no odour. On standing, a small light flocculent deposit.	3·82	0·05	3·87	0·78	2·1
6. In plantation, about 990 yards below No. 1.	Do.	3·60	0·06	3·66	0·87	1·8
8. At junction with North Calder, about 1,276 yards below No. 1.	Clear and transparent, no odour. On standing, trace of deposit.	1·66	0·06	1·72	0·52	0·

NOTE.—Nitrites and Nitrates were absent in all the above samples except No. 5, which contained Nitrites amounting to ·02 pts. (NO_2) per 100,000, and No. 8, which contained Nitrates amounting to 2·12 pts. (as NO_3) per 100,000, estimated by Indigo Carmine.

Table Z.—Production of Sulphate of Ammonia in Scotland.

From	Average Number of Works in				Average Quantity Produced Yearly stated as Sulphate of Ammonia—in Tons.		
	Scotland.		Lanarkshire.				
	1892-1901.	1902.†	1892-1901.	1902.†	1892-96.	1897-1901.	1902.†
Shale Works, - -	16	13	2	1	32,127	38,095	36,931
Iron ,, - -	13	15	8	9	11,761	17,008	18,183
Gas Liquor Works, -	33	35	3	4	12,217	15,053	18,205
Producer, Gas, Coke, &c., Works, - -	4	3	2	1	...	2,355*	2,964

*Average of production during years 1899, 1900, and 1901; figures for previous years included under "Gas-Liquor Works."

† The figures given for 1902 are totals.

Note.—During the years 1895-1901 the amount of pitch produced at the above works was 851,466 tons, and during the year 1902, 146,836 tons.