Rivers pollution (Scotland) : report to Her Majesty's Secretary for Scotland / by Alfred E. Fletcher ; presented to both Houses of Parliament by command of Her Majesty.

RIVERS POLLUTION [SCOTLAND].

REPORT

8.

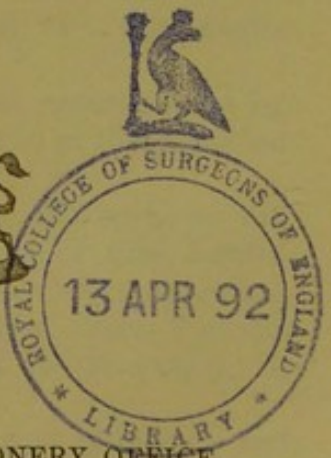
TO

HER MAJESTY'S SECRETARY FOR SCOTLAND.

BY

ALFRED E. FLETCHER, ESQ., F.C.S., F.I.C.,
INSPECTOR FOR SCOTLAND UNDER
THE RIVERS POLLUTION PREVENTION ACT, 1876.

Presented to both Houses of Parliament by Command of Her Majesty.



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RIVERS POLLUTION PREVENTION ACT, 1876.

To the most Honourable the Marquis of Lothian, K.T., Her Majesty's Secretary for Scotland.

My Lord Marquis,

I have the honour to submit a report of the work done in Scotland under the Rivers Pollution Prevention Act since my appointment as Inspector in February 1886.

The duty to which I was first called was to examine the water of the River Gala, and in particular the effluent from the dye works of Messrs. Brown Bros. in consequence of their application for a certificate as provided in clause 12 of the Act.

A prolonged litigation had been carried on between the riparian owners on the Tweed and the proprietors of certain public works on the Gala with a view to prevent the latter from polluting the water of the river. In consequence of this, extensive apparatus had been erected at several of the works referred to, in order to purify the water after their use of it, before it re-entered the river. At the works of Messrs. Brown Brothers large settling tanks and filter beds had been constructed. These appeared to be very successful in accomplishing the end in view. I brought away specimens of the water thus purified and submitted them to chemical examination. The detailed results were given in my report at the time (*see* report in Appendix No. 1). The certificate was, however, not granted, as the applicants neglected to comply with the conditions imposed by the Act.

In April 1886 I received instructions from the Secretary for Scotland to visit Auchterarder and report on the water of the Ruthven said to be polluted by the action of two dye works situated on its banks.

My report confirmed the allegation, and was accompanied by suggestions as to a method by which a continuance of the pollution might be avoided. (*See* report in Appendix No. 2.)

A direction to enforce these suggestions was addressed by the Secretary for Scotland to the sanitary authorities of the district of Aberruthven. The sanitary authorities, however, exercised the discretion allowed them under the provisions of clause 7 of the Rivers Pollution Prevention Act and declined to take action in the case.

In August 1886 I received instructions to visit Milngavie and report on the condition of the River Allander.

I pointed out in this case several sources of pollution arising from certain public works both in and below the burgh. (*See* Appendix No. 3.)

My report was forwarded to the local authority, who adopted the suggestions contained in it. The methods proposed have proved successful and those who formerly complained have expressed themselves as satisfied with the result.

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Since that date until September 1887 I have not been called to take further action under this Act.

In that month I received instructions from the Secretary for Scotland to examine into and report on the alleged pollution of the waters of Loch Long and Loch Goil. This was done ; specimens of the water from those and the neighbouring lochs were collected ; also portions of the muddy deposit found at the bottom of the lochs. In all 69 specimens were collected and submitted to chemical analysis. A detailed report has been presented, and is given here in Appendix No. 4.

Sufficient time has now elapsed since tbe passing of the Rivers Pollution Prevention Act, 1876, to make this a fitting occasion for offering some remarks on it in the hope that opportunity may be found for effecting amendment where that may appear to be necessary.

Under this Act various operations which might lead to the the pollution of streams and watercourses are prohibited, such as placing any solid matter in them or allowing any polluting liquid to enter; none, however, but a sanitary authority can enforce these provisions or take proceedings against an offender. In certain cases the central authority may order such proceedings to be taken (clause 6), but the local authority may then exercise its discretion as to whether it shall obey such order or not.

Cases often occur where the local authority or those who have influence with it are themselves the offender. It is evident that in such cases the Act may become inoperative.

In the case already referred to, when an inquiry was instituted as to an alleged pollution of the River Ruthven, the local authority exercised the discretion allowed them under clause 6 of this Act and declined to carry out the direction of the Secretary for Scotland in the matter, thus frustrating the object of the inquiry.

Objection may also be raised as to the provisions of clause 12 whereby an inspector under the Act is empowered to grant to a manufacturer or other user of water a certificate that he has employed "the best or only practicable and available means for "rendering harmless the polluting solid or liquid matter falling or "flowing into any stream." Such a certificate may remain in force for two years, and is to be held "in all courts and in all proceed-"ings under this Act as conclusive evidence of the fact."

It should be noticed that although the Inspector has power to grant this certificate, the effect of which may extend over two years, and shelter the holder from further legal action on the ground of having caused the pollution of water, yet he has no power of ascertaining whether those "best and practicable means" for which be has certified are continuously practised, or whether on the granting the certificate they are allowed to lapse into disuse.

I would submit that clauses 6 and 12 should be removed from the Act and that provision should be given for the appointment of a Chief Inspector and district Inspectors as under the Alkali Act.

To them would be entrusted the working of the Act, prosecutions being conducted by the Chief Inspector with the consent of the central authority.

There is much to be said in favour of the definition given in the Act of an offence against its provisions, as being a neglect to use the "best practicable means" for avoiding the pollution of water. Attempts have been made to establish standards whereby an alleged pollution of water should be judged.

The substances likely to be found as sources of the pollution of water have been named and a proportion fixed as a standard. The amount is stated in terms of grains per gallon. Should a substance be found present in larger proportion than that fixed as a standard quantity it would be held to be a pollution of the water.

It was found, however, difficult to decide on such standards, those which were practicable in some cases were shown to be impossible of adoption in others. Nor is it difficult to see that this must be so. Taking the case of a stream on the banks of which are many factories, such as dye works, chemical works, &c. it would be unreasonable to expect that the water received by the lower works would be quite as free from taint as that which reaches the works higher up the stream, although the defilement may have been confined within the narrowest practicable limits. It follows, therefore, that the same standard of purity cannot be applied to the effluent water from all these works, since the lower ones receive the water in the condition in which it is discharged from those higher up the stream.

To give an instance, there may be ten works using water successively from the same stream. If a fixed standard of purity is adopted then it will be incumbent on each user of the water to return to the river the water they have used in a condition conformable with the standard. At Works No. 1, drawing water near the source of the stream; this can probably be done, since there is the margin between good river water and the condition defined by the standard. At Works No. 2, situate lower on the stream than Works No. 1, this working margin will be much diminished, and at the works still lower down the water may be received in a condition so barely within the standard that they cannot use it even in the most guarded manner without passing the line and rendering themselves liable to prosecution. The same fixed standard is therefore not applicable to all.

Let each, however, be compelled to use the "best practicable means" for maintaining the purity of the water and it would be found that standards of purity, although not fixed in an Act of Parliament, would become established. Standards would grow up and be formed subject to the stress of conflicting interests. They would vary with the place, the volume of the stream and the service to which the water is subject. Moreover, they would vary with the increase of knowledge, for as improved chemical and mechanical appliances become available for the prevention of

pollution, so is it reasonable to apply ever higher standards of purity in judging the quality of the water treated by them. The very method of defining the quality of water is subject to change with the growth of chemical knowledge. The adoption in an Act of Parliament of fixed standards in such a case is the petrifaction of that which should be endowed with life and be capable of continuous growth. On the other hand, the enactment that all users of water must adopt the "best practicable means" to prevent its pollution is but the enforcement of a responsibility which none can with reason repudiate.

It may be asked, Who is to be the judge as to what are the best practicable means in a given case? I reply that, fortunately, this abstract question never need be answered. It is sufficient if, judging by the result of the method employed as compared with the result achieved by others in like circumstances, the Inspector can point to failure; if he can show that here the best methods have not been used. He need not go further and say what are the best methods; it is sufficient if he can point to some better ones which are available.

It is my opinion that, for the reasons given, this Act would be rendered much more effective if clauses 6 and 12 were repealed and the responsibility of carrying out its provisions placed in the hands of a Chief Inspector, assisted by district Inspectors, rather than as now in the hands of the local sanitary authority.

I am, &c.

(Signed) ALFRED E. FLETCHER,
Inspector for Scotland under the
Rivers Pollution Prevention Act.

February 10th, 1888.

APPENDIX No. 1.

Pollution of the River Gala.

Report on the Effluent Water from the Dye Works of Messrs. Brown Bros. at Galashiels.

To the Secretary for Scotland.

My Lord, 21st May 1886.

Herewith I return the papers forwarded to me from your office on the 9th March.

They refer to the pollution of the River Tweed by the effluent water from mills at Galashiels on the River Gala, and include a letter from Mr. James Brown, one of the proprietors of Buckholm Mill, asking that your Inspector under the above-named Act should examine their water purification works recently erected, and, if possible, grant a certificate of efficiency as provided in section 12 of the Act.

In accordance with your instructions which accompanied this I have now visited the works of Messrs. Brown Brothers and examined the arrangements in operation there for purifying the water used in the dying, scouring, and other operations before it is allowed to re-enter the River Gala. I have also brought away samples of the water so purified, and by chemical analysis ascertained the condition of the same.

The principal impurities in the waste water from the dye works are soap, coloured dye-stuffs, and certain mineral matters held in solution.

In order to free the water from these the discharged liquors from the various portions of the work are led into tanks where, mixing together in certain proportions and with the careful addition of small quantities of such materials as sulphuric acid, lime, alum, and a salt of iron &c., the coloured matter and other impurities are precipitated, together with the major portion of the materials added. The solid matter thus deposited separates by subsidence, and the water is finally cleansed by filtration.

The result of these operations is that the discharge from the mill on entering the Gala is neutral, clear and colourless, and contains in solution only salts of lime and such other similar ingredients as are found in natural waters.

The quantity of water daily treated is stated at between 35,000 and 40,000 gallons.

In order to carry out this natural process of precipitation and filtration an extensive system of purification works has been constructed.

They consist of—

	Gallons.
Wool scouring, settling, and collecting tanks -	14,500
Five Magma tanks - - - -	12,400
Acid tank - - - - -	10,000
Two dye settling tanks - - -	23,500
Dye collecting tank - - - -	29,700
Lime-water tank - - - -	9,000
Six precipitating tanks - - -	27,000
Neutralizing tanks - - - -	8,100
Two filter tanks - - - -	12,300

One 8-inch pump and one filter press.

The question now arises, Can a certificate be given to the owners of this work as contemplated in section 12 of the Act, stating that the means here used for rendering harmless any polluting matter passing into the stream are the best or only practicable and available means under the circumstances of the particular case?

My examination of the means employed and of the result attained leads me to report favourably.

The works are well calculated to accomplish the end in view. They are wisely planned, substantially built, of a permanent character, and the result of their operation on the day I examined them was satisfactory.

Under these circumstances I feel justified in giving a certificate as contemplated in the Act.

It must be born in mind, however, that such an arrangement of settling tanks and filter beds is not and cannot be made self-acting, and that the future effective working of the apparatus must depend largely on the skill of those employed to work it. This points to the necessity of an independent Inspector who in a district like that of Galashiels, and the neighbourhood should keep constant watch over the condition of the water discharged from the various dye works, &c. into the river.

As regards, however, the works constructed and now employed for the purification of the water discharged from the Buckholm Mill at Galashiels I think the owners are entitled to a certificate given in the terms of section 2 of the Rivers Pollution Prevention Act, 1876.

I am, &c.

(Signed) Alfred E. Fletcher,
Inspector for Scotland under the
Rivers Pollution Prevention Act.

Analysis of Gala Waters.

—	Suspended Matter.	Total Solids.	Loss on Ignition.	Silica.	Lime.	Alumina.	Chromic Oxide.	Magnesia.	Sulphuric Anhydride.
	Parts per 100,000.								
No. 1. River Gala above mill (in half flood).	Trace	9·8	2·2	0·3	1·346	1·2	—	0·871	1·099
No. 2. Effluent after leaving filter beds.	2·6	100·6	3·6	0·3	12·12	1·2	21·8	0·726	43·56
No. 3. Water from rinsing process.	6·4	8·6	1·6	0·4	Not estimated.	Not estimated.	Not estimated.	Not estimated.	Not estimated.
No. 4. Second sample of rinsing water, sent by Messrs. Brown Bros.	5·2	10·4	1·8	0·8	1·57	—	—	0·871	1·649
	Grains per Gallon.								
No. 1 - - - -	Trace	6·86	1·54	0·21	0·942	0·84	—	0·609	0·769
No. 2 - - - -	1·82	70·42	2·52	0·21	8·484	0·84	15·26	0·508	30·492
No. 3 - - - -	4·48	6·02	1·12	0·28	Not estimated.	Not estimated.	Not estimated.	Not estimated.	Not estimated.
No. 4 - - - -	3·64	7·28	1·26	0·56	1·099	—	—	0·609	1·154

APPENDIX No. 2.

Pollution of the River Ruthven.

TO THE SECRETARY FOR SCOTLAND.

MY LORD, 29th July 1886.

ON the 5th April I received your instructions to institute an inquiry under section 6 of the Rivers Pollution Prevention Act (39 & 40 Vict. c. 75.), into the matters complained of in certain letters addressed to the Secretary of State for the Home Department by Mr. David Whyte, of Forfar, calling attention to an alleged pollution of the River Ruthven, and to report to your Lordship thereon.

Accordingly, on April 22nd, I visited the district and examined the course of the River Ruthven. I invited the villagers and proprietors residing on the banks of the stream to meet me, and

also the dyers who were the supposed authors of the alleged pollution. Mr. Treasurer, sanitary officer of Auchterarder, was also present.

Among these there was an agreement of testimony that the water of Mill Lade containing that portion of the River Ruthven which passed through the two dye works in the district was often discoloured and polluted by the refuse liquors there allowed to enter it. This pollution was intermittent, being greater at the time when the spent dye liquors were discharged. These facts were not disputed by the dyers, but they denied that their operations were sufficiently large to constitute a serious pollution of the water. They also claimed a prescriptive right to the use of the water in their dye works.

I ascertained that the sewage water of the town of Auchterarder after filtering over the surface of a meadow passed into the Ruthven.

I then collected samples of the water of the stream and of the sewage water after its passage over the irrigated meadow; also specimens of the spent dye liquors which are from time to time discharged from the dye works. At the time of my visit the water of the stream was but slightly discoloured. I therefore desired two of the complainants to forward me a specimen of the river when the pollution, judging from the colour, was at its height. This they did. The spent dye liquors as discharged from the dye works before dilution with the water of the brook are strongly coloured with dye stuffs and contain in solution soaps, acids, chromates, and other salts.

The various specimens of water so collected were afterwards analysed. The results are given as an appendix to this report. On reference to this it will be seen that the pollution and discoloration, though not great when compared with that found in many manufacturing districts, is still considerable, and should be avoided as far as is practicable without seriously burdening the dyeing industry there carried on.

In my opinion much might be done in this direction by the dyers without entailing great expense. A great part of the material held in solution in the waste liquors referred to may be precipitated and separated from the water by the simple mixing together of the liquors themselves with a proper addition of lime and afterwards correcting the alkalinity by sulphuric acid. This is done successfully by dyers in other places, notably by those at Galashiels. The expense involved in such operations would be limited to that of constructing a settling pond on the adjacent land and pumping the waste liquors into it. After time has been allowed for the mixture to subside and clarify, clear water may be drawn from the top and discharged into the river. The details of such an operation are such as any dyer versed in the chemistry of his art will readily be able to arrange.

As a result of my investigation of this case I am of opinion that there is pollution of the water of the Ruthven, caused by the operations carried on at the dye works of Messrs. James Caw and

Peter Duff; that many means are within their reach of preventing or largely mitigating this pollution; and that they should be called upon by the sanitary authority to employ such means, as is directed in section 4 of the Rivers Pollution Prevention Act.

I am, &c.

(Signed) ALFRED E. FLETCHER,
Inspector for Scotland under the
Rivers Pollution Prevention Act.

Analysis of Ruthven Waters.

—	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Nitrates estimated as Nitrogen.	Matter in Suspension.	Solids in Solution.
	Parts per 100,000.					
No. 1. Ruthven Mill Lade, 1.45 p.m., 24th April 1886.	·000	·008	1·1	0·0	11·0	11·0
No. 2. River Ruthven, 29th April 1886 -	·000	·009	1·1	0·0	2·0	10·8
No. 3. Mill Lade, Ruthven, 17th May 1886 -	·0025	·015	0·9	Trace	6·0	12·0
No. 4. Sewage of Auchterarder, after passing over meadow, about to enter the Ruthven, 24th April 1886.	·002	·048	2·8	0·15	15·0	27·0
No. 5. Do. do. 3rd May 1886	·090	·021	3·0	0·30	Trace	28·0
	Grains per Gallon.					
No. 1 - - - - - -	·000	·0056	0·77	0·0	7·7	7·7
No. 2 - - - - - -	·000	·0063	0·77	0·0	1·4	7·56
No. 3 - - - - - -	·0013	·0105	0·63	Trace	4·2	8·4
No. 4 - - - - - -	·0014	·0336	1·96	0·105	10·5	18·9
No. 5 - - - - - -	·063	·0147	2·1	0·21	Trace	19·6

APPENDIX No. 3.

Pollution of the River Allander.

To the Secretary for Scotland.

My Lord

In accordance with instructions received from the Secretary for Scotland, dated August 5th last, I have visited the town and neighbourhood of Milngavie to examine into the alleged pollution of the River Allander there, and now report as follows :—

The sources of pollution are certain public works situated on the banks of the river, above, within, and below the burgh. These works are found in the following order of position on passing down the stream :—

Above the burgh.	Tambowsie Distillery - -	I.
	Craighton Yarn-Bleach Work -	II.
	Clober Piece-Bleach Work - -	III.
	Allander Bleach Work or Laundry -	IV.
Within the burgh of Milngavie.	Ellangowan Paper Mill - -	V.
	Allander Print Work - -	VI.
	Sewage outfalls - - -	VII.
Below the burgh.	Burnbrae Dye Work - -	VIII.

The annexed table (pp. 15, 16) gives the results of the analyses of samples of water taken from various parts of the river, and shows the progress of pollution on passing down the stream. The samples were taken on the 28th and 30th August last, at a time when the river was neither in flood nor very low.

I. The Tambowsie Distillery.

This was not at work; when in operation, however, the 'potale,' or distillers' refuse, is run into the river. In some similar cases this is prevented by using the liquor for irrigating land or for feeding cattle.

II. Craighton Yarn-Bleach Work.
III. Clober Piece-Bleach Work.

In both these works water from a mill lade, a portion of the river, is used to drive machinery and for rinsing the goods under process of bleaching. The materials thus added to the water are chiefly of a mineral nature, and as to quantity and quality, do not constitute a serious pollution of it. This will be seen on reference to columns I., II., III., and IV., and to column V. which gives the analysis of the river itself further down the stream.

Passing down the stream the next work is that of—

IV. The Allander Bleaching Company—a Steam Laundry.

Some soapy water here reaches the river, but the amount is not sufficient to constitute a serious pollution. Column V. shows the condition of the water at a point below all these works but before it reaches the burgh of Milngavie. It is here a good water, but shows a trace of organic matter of animal origin, probably contributed by the drains from some houses to be seen on the banks of the river further up stream. Column VI. shows the character of the water after having passed the burgh. It is discoloured and smells strongly of sewage, becoming very putrid after a few days. The quantity of matter in suspension and solution has been increased more than threefold, and indication is given of the presence of much decomposing animal matter. It is wholly unfit for drinking.

The sources within the burgh of this pollution are—

V. The Ellangowan Paper Mill.

The result of analysis of a sample of water taken from the main effluent is shown at column VII. There is a considerable increase in the amount of suspended matter, and the water is discoloured.

Very much has been done by the proprietors of this work to diminish the pollution of the stream. The bleaching residues are now allowed to flow into a pit from which the clear water alone can enter the river while the solid deposit of lime, &c. is carted away. Formerly the whole of this passed into the river.

Until lately a large quantity of water containing alkali, the rinsings of fibre after treatment with caustic soda, was allowed to reach the river. This source of pollution is now entirely removed by the recent erection of a "Porion" evaporator, by means of which the whole of this alkaline and coloured water is given off as steam, the alkaline matter being at the same time recovered.

At present the water leaving this paper mill is objectionable, chiefly on account of its turbidity, due to fibre and mineral matter held in suspension. There are, however, at present several large filter beds not now in use. If the effluent water were passed through these a very good result might be anticipated.

Column VIII. shows the character of a minor effluent from this paper mill. It contains some soap and grease. The amount of water is small and might be readily dealt with.

VI. The Print Work of Messrs. Thompson, Robertson & Co.

Here the effluent waters are collected in a large pond or reservoir, the overflow from which passes into the river. Column IX. shows its composition. It is coloured and contains some arsenic, but not in sufficient quantity for its presence

to be detected in the water of the river. This effluent might be much improved and all arsenic removed by the occasional addition to the pond of certain inexpensive precipitants, as sulphate of iron, alum, lime, &c., when the condition of the water is found to need it.

VII. The Sewage of the Town.

This enters the river at three principal places, and at some minor ones within the burgh. It is subject to no treatment, but flows direct into the river. There is land convenient as to level and position which might be utilised for the purpose of precipitating the sewage. The clarified liquid could then be allowed to percolate over grass meadows before reaching the river.

Below the burgh is—

VIII. The Burnbrae Dye Work.

An analysis of the water flowing from this work is given at column X.

Here great effort has been made to avoid pollution of the water. Several large settling tanks have been erected. It would appear, however, that a more successful use might be made of them by a watchful attention to the condition of the effluent. The specimen I took is very heavily charged with matters in solution, reaching 54·46 grains per gallon. Much of this may be readily precipitated and separated by the addition of a small quantity of lime; the deposit formed separates rapidly and completely. The water is thus rendered clear and colourless.

To sum up the foregoing it may be said that the water of the River Allander below the burgh of Milngavie is much polluted with sewage and by the effluents from public works, chiefly within the borough. Almost the whole of this might be removed or prevented by the adoption of simple means, such as would readily suggest themselves to a skilled person.

I am, &c.

(Signed) Alfred E. Fletcher,
Inspector for Scotland under the
Rivers Pollution Prevention Act.

12th October 1886.

Samples were also taken from three of the effluents from the Burnbrae Dye Work before they enter the settling ponds. The analyses are given on pp. 15 and 16.

A. E. F.

——	I. Craighton Burn before reaching the Bleach Work, 30th August 1886.	II. Effluent from Craighton Yarn Bleach Work, 30th August 1886.	III. Water of Mill Lade, Clober Field Bleach Work, 30th August 1886.	IV. Effluent from Clober Field Bleach Work, 30th August 1886.	V. Water taken above Borough of Milngavie, near Clober Lodge, 28th August 1886.	VI. Water taken below Borough of Milngavie, the River neither in Flood nor Low, 28th August 1886.	VII. Ellangowan Paper Mill, final Effluent, 27th August 1886.	VIII. Ellangowan Paper Mill, small Effluent, 27th August 1886.	IX. Thompson, Robertson, & Co., Print Work, Effluent Water from Settling Pond.	X. Burnbrae Dye Work, Effluent from Ponds, 27th August 1886.
Suspended matter	0·0	Trace	Trace	Trace	0·2 *0·14*	3·4 *2·38*	7·6 *5·32*	Not estimated.	Small quantity.	Not estimated.
Total solids in solution	8·2 *5·74*	13·0 *9·1*	8·2 *5·74*	9·0 *6·3*	8·2 *5·74*	23·2 *16·24*	12·0 *8·4*	26·6 *18·62*	22·8 *15·96*	77·8 *54·46*
Loss on ignition	—	4·2 *2·94*	2·8 *1·96*	—	2·8 *1·96*	8·0 *5·6*	2·6 *1·82*	Chiefly due to fatty matters 18·8 *13·16*	11·2 *7·84*	26·0 *18·2*
Mineral constituents of solids	—	8·8 *6·16*	5·4 *3·78*	—	5·4 *3·78*	15·2 *10·64*	9·4 *6·58*	7·8 *5·46*	11·6 *8·12*	51·8 *36·26*
Chlorides, as Cl	—	1·3 *0·91*	—	—	0·95 *0·665*	2·7 *1·89*	—	1·4 *0·98*	0·6 *0·42*	17·5 *12·25*
Silica, $Si\,0_2$	—	—	—	—	0·5 *0·35*	0·4 *0·28*	—	0·4 *0·28*	0·6 *0·42*	0·8 *0·56*
Iron and alumina oxides, $Fe_2\,0_3 + Al_2\,0_3$	—	0·6 *0·42*	—	—	0·4 *0·28*	1·1 *0·77*	—	—	1·0 *0·7*	2·0 *1·4*

N.B.—Roman figures = Parts per 100,000 gallons of water.
Italic figures = Grains per gallon.

Allander Waters—*continued.*

——	I. Craighton Burn, before reaching the Bleach Work, 30th August 1886.	II. Effluent from Craighton Yarn Bleach Work, 30th August 1886.	III. Water of Mill Lade, Clober Field Bleach Work, 30th August 1886.	IV. Effluent from Clober Field Bleach Work, 30th August 1886.	V. Water taken above Borough of Milngavie, near Clober Lodge, 28th August 1886.	VI. Water taken below Borough of Milngavie, the River neither in Flood nor Low, 28th August 1886.	VII. Ellangowan Paper Mill, final Effluent, 27th August 1886.	VIII. Ellangowan Paper Mill, small Effluent, 27th August 1886.	IX. Thompson, Robertson, & Co., Print Work, Effluent Water from Settling Pond.	X. Burnbrae Dye Work, Effluent from Ponds, 27th August 1886.
Chromic oxide, $Cr_2 0_3$	—	0·0	—	—	—	0·0	—	—	0·0	2·4 *1·68*
Arsenious acid, $As_2 0_3$	—	0·0	—	—	—	0·0	—	—	1·121 *0·084*	0·0
Lime, Ca 0	—	1·57 *1·099*	—	—	1·68 *1·176*	5·05 *3·53*	—	—	2·47 *1·729*	4·48 *3·136*
Magnesia, Mg 0	—	0·72 *0·504*	—	—	0·36 *0·25*	0·4 *0·28*	—	—	0·48 *0·336*	4·376 *3·063*
Sulphates, S 0_3	—	—	—	—	1·099 *0·769*	2·06 *1·44*	—	—	2·3 *1·61*	4·396 *3·077*
Free ammonia	—	—	—	—	0·004 *0·003*	0·014 *0·0098*	—	—	—	—
Albuminoid ammonia	—	—	—	—	0·01 *0·007*	Very high (about 0·09)	—	—	—	—
Nitrates, as nitrogen	—	—	—	—	0·049 *0·034*	0·05 *0·035*	—	—	—	—

N.B.—Roman figures = Parts per 100,000 gallons of water.
Italic figures = Grains per gallon.

APPENDIX 4.

Report on the Pollution of Loch Goil and Loch Long.

To the Most Honourable the Marquis of Lothian, K.T.

My Lord,

On receiving your instructions, dated 2nd September, to make an examination of the waters of Loch Goil and Loch Long in reference to an alleged pollution of the same, I commenced the inquiry, communicating first with Dr. Littlejohn, of Edinburgh, as desired. He gave me much useful information as to those who had made complaint in this matter.

Proceeding to the immediate neighbourhood of the alleged nuisance, I found that very many of those who resided on the coast complained of the growing impurity of the water. A feature noticed by all was the scum floating on the surface, especially discernible in calm weather.

Those who were accustomed to bathe in the water complained very much of this, as did also the fishermen; these alleging that their lines were made foul, covered with a slimy substance, and that fish had become scarcer of late years.

The following are believed by the residents to be the principal sources of pollution to which these lochs are exposed:—

1. The dredgings of Glasgow Harbour and the Clyde, containing the portion of sewage matter which has settled in the bed of the river. These are brought in barges, and deposited at the entrance to, or southern end of Loch Long. The quantity so brought is 1¼ million tons per annum.

   Also the dredgings from Greenock Harbour.
2. The deposit of about 150 tons a week of tank waste brought from an alkali work and discharged at the southern end of Loch Long.
3. The water of the River Clyde bringing down with it the sewage of Glasgow.
4. The drainage from the villages and country houses on the shores of the lochs.
5. The soot settling from the smoke of numerous steamboats plying on the Clyde and on the lochs in question.
6. Cinder and other refuse thrown out from the steamboats referred to.

It was contended by some that these sources of pollution, though extensive, were not sufficient seriously to affect the large volume of water daily entering and leaving the loch. They believe that

if it were not for the vision of barges bringing the objectionable matter for deposit in the loch no pollution of the water would be noticed. In pursuing, therefore, the inquiry in hand it seemed necessary to determine—

1st. Whether the pollution was such as to justify the complaints made.

2nd. Which were the sources of such pollution.

3rd. What remedies could be suggested for removing them.

It could not be said that the pollution was such as to appeal strongly to the eye; the water did not appear wanting in brightness.

Occasionally it was said that the water looked dirty, but this was not the case in my experience. I therefore collected specimens of the water, placing them in well-stoppered bottles, and brought them away for analysis. These were taken not only from the neighbourhood where the Clyde dredgings are deposited, but at intervals of a few miles throughout the extent of the lochs, and also from some of the neighbouring lochs, so as to afford opportunity for comparison. The specimens were taken at low water.

The water of the lochs is deep, reaching to 30 and 40 fathoms in the middle. The bottom is usually covered with a soft mud, the result of a slow deposition from the water. Believing that an examination of this would indicate the locality and nature of the sources of impurity, I collected specimens over an extended area reaching at intervals throughout the whole length of Lochs Long and Goil. Some also were taken from neighbouring lochs and a portion of the River Clyde.

I did not fail also to collect portions of the scum which, in calm weather, floats on the surface of the water. Of this there are two kinds, one being composed chiefly of soot which has fallen from the smoke of steamboats; the other is brown in colour, and is seen as a thin film when the water is still. The deposits of soot may be observed on the Firth of Clyde far below the entrance to Loch Long, lying in patches in calm weather as far south as Rothesay. This soot, drifting by help of tide and wind, is seen at the southern portion of Loch Long. Further up the Lochs Long and Goil, and even at the head of either loch, may be found a scum brown in colour, which, when kept for a short time in a closed vessel, becomes highly offensive, and consists, doubtless, of sewage matter a suspicion which is confirmed by the analyses.

On submitting to analysis the specimens of water and mud it would have been very desirable if a test could have been devised which would have shown a distinction between matter derived from town sewage and organic matters of marine origin. This, however, was not found to be possible; I have given, therefore, the total amount of organic matter and of nitrogen present, affording thus a measure of the total amount of impurity present from all sources.

Nitrogen, although found in organic matter of marine origin, occurs in larger proportion in the constituents of sewage. Thus the water and the mud taken from Glasgow Harbour contain very

much more nitrogen than do any of the other specimens. *See* analyses No. 1 and A.

In submitting, in tabular form, the results of the analyses, it should be mentioned that about three weeks elapsed between the time of collecting the samples and of performing the chemical examination, but all were examined as nearly as possible at the same time. This should be borne in mind when comparing the figures with the amounts found by others. Such series are chiefly valuable for comparison *inter se.*

The amount of "oxygen consumed" was determined after the manner recommended by Forschammer; the action of permanganate of potash being continued during three hours.

On examination of the muds it was found desirableto separate the light flocculent matter from the sand. This was most conveniently effected by allowing a gentle stream of water to enter at the bottom of a tall glass in which a weighed portion of the mud had been placed, and continuing the flow until the lighter particles had been removed. These were dried at 100° C. and weighed. The "organic matter" is the subsequent loss on incineration.

The "nitrogen" was determined by distillation with alkaline permanganate.

The "fatty matters" given in the examination of scums is the portion soluble in ether.

The results of the analyses of the various specimens of water are indicated by letters, which are also marked in the attached map at the places where the specimens were taken. They are arranged in the order preceding from the entrance to the head of the loch.

Those of the various specimens of mud from the bottom of the lochs are distinguished by numbers, which are also marked on the map.

Commencing with the water of Glasgow Harbour, the analysis shows clearly the presence of sewage contamination, and this is indicated in lesser degree in the Clyde water as it passes Greenock, Gourdock, and the Cloch Point. The same is shown by examination of the mud taken from the same places. The waters of the Lochs Long and Goil and Holy Loch show no such marked indication of pollution, but they are inferior to those of Lochs Striven and Ridan.

For more than 20 years it has been the custom to make the entrance to Loch Long the place of deposit for the mud which is dredged up from Glasgow Harbour and from the bed of the River Clyde. As much as 1¼ million tons of this material are annually brought here. It might have been expected that the material found in the bottom of the loch at intervals throughout its length would have shown the presence of this mud, diminishing in amount as the distance from the place of deposit increases. An examination of the analyses does not, however, show this to be the case. There is evidence of sewage mud at the place of deposit (*see* samples 18 to 22), but no gradual diminution in the per-centage of nitrogen in proportion as the distance from the place of deposit is increased. Probably when a discharge of sewage mud is made in

the loch at the time of flood tide, the finer portions floating long in the water are carried up the loch for a considerable distance. During this transit they become oxidised and innocuous. It is possibly during this process that a portion of the material in process of decomposition rises to the surface, to assist in forming the scum so much complained of.

The soft, slimy deposits are the most nitrogenous, and occur in the still, deep places, increasing toward the head of the lochs, where the tidal currents are feeble. On banks, or in places where a swifter current has left the deposit more sandy, the soft, nitrogenous matter is removed. The amount of this does not therefore depend on the nearness to the place of deposit of the dredging at the entrance to the Loch Long, but rather on the stillness of the water. Also in Loch Striven the mud taken from the head is more nitrogenous than that taken from the entrance to the loch, and, with the exception of one specimen, is as nitrogenous as that found at the heads of Lochs Goil and Long.

An examination of the sheet of water analyses shows the water of Loch Long to be slightly inferior to that of Loch Goil, while both are superior to that of the Holy Loch, but inferior to that of Lochs Striven and Ridan.

Mention has been made of the scum found in still, warm weather on the water of Lochs Long and Goil, more or less throughout their whole length, and at the head of the lochs. An analysis of it is given. After being kept a few days the material became highly offensive, and was evidently largely composed of sewage matter. A quantity was collected at the head of Loch Goil, at a distance of 12 miles from the entrance to Loch Long, where the dredgings, &c. are deposited.

It cannot be doubted from the foregoing evdience that the complaints raised as to the pollution of the water of Lochs Long and Goil are well founded. Also, it may be said that the pollution is occasioned by one or more of the six sources already set forth. All of them are at work, and contribute to the evils; most of them may be removed.

Taking the sources of pollution in order :—

No. 1. The dredgings from Glasgow Harbour and other places, which are deposited in Loch Long to the amount of 1¼ million tons a year, also those from Greenock.

The principal argument in favour of the practice is its convenience. Many, however, believe that places of deposit might be found on the banks of the Clyde where these dredgings would make good land, instead of, as at present, spoiling good water. The amount, if placed with an average thickness of nine feet on the land, so as to raise it above high-water mark, would recover 100 acres every year. There appear to be many portions of the foreshore where this treatment would be suitable, and where the land so recovered would be of considerable value.

No. 2. The deposit of tank waste from an alkali work.

The action of this has certainly been injurious to the water. This material, though not soluble in water *per se*, becomes so on absorption of oxygen, yielding a sulphurous liquid poisonous to fish,

Experiment shows the solution of the material goes on more rapidly in sea water than in fresh. I have taken it on me to represent to the Directors of the North British Chemical Company the evil caused by their depositing the "waste" here, and have already received an assurance that the same shall cease not later than March 1st next.

No. 3. The influx of impure water from the Clyde at the mouth of Loch Long.

This must obviously be a source of pollution as long as the sewage of Glasgow flows down the Clyde. If, as is asserted by some, the direct outward flow of the River Clyde is confined to the Greenock shore, yet on the return tide some of the impure water will certainly be brought back.

No. 4. The drainage from villages and houses on the shores of the lochs.

It seems to me most probable that the scum found floating on the water is partly of local origin. It is not offensive when gathered, but becomes highly so when kept. It is found on all lochs which I examined, but mostly where there are houses. Traces of it were found on Loch Striven. As a remedy for this it may be suggested that, as far as possible, by the use of earth closets and catch-pits, all house drainage should be kept out of the lochs.

No. 5. The soot caused by the numerous steamboats plying on the lochs and on the Clyde falls on the water, and in calm weather collects in patches. It may be observed floating with the tide and drifting into the lochs. The whole of this, and the black smoke sent forth from the steamboat funnels, is curable, and that without loss to those who now carelessly produce it. Pressure is needed to compel the constructors of the boilers, and those who use them, to cause the nuisance to cease. At present the practice is not forbidden, except when the vessel is alongside a pier or wharf.

No. 6. Refuse thrown out by passing steamboats.

This doubtless contributes to the general result. It must be small, however, compared with the other sources of nuisance.

These, I believe, to be the causes of the pollution of the waters referred to, and the remedies, as far as I am able to point them out. The sources of pollution are many; if all of them cannot be at once removed, this should not be pleaded as a ground for inaction. The principal one, that of making Loch Long a receptacle for the refuse of Glasgow and the neighbourhood, may be pointed out as a gross evil which should now be stopped.

Although for many years a vast amount of material has been thrown into the loch, the soundings are not materially altered at the place of deposit, showing that the mud, &c. has been carried away by the tide far up into the loch.

I am, my Lord Marquis,
Your most obedient Servant,
(Signed) ALFRED FLETCHER,
Inspector for Scotland under the
Rivers Pollution Prevention Act.

Enclosure in Appendix 4.

Clyde Water.

—	Description of Sample.	Oxygen consumed per 100,000.	Free Ammonia per 100,000.	Albuminoid Ammonia per 100,000.	Total Ammonia per 100,000.
A.	Glasgow Harbour water (stinking badly, bad colour).	0·280	0·260	0·040	0·3
B.	Between Princes Pier and Roseneath Point.	0·17681	0·007	0·004	0·011
C.	Between Gourock and Burren Point.	0·0846	0·006	0·004	0·01
D.	Between Hunter's Quay and Clock Lighthouse, $\frac{1}{3}$ distance from Hunter's Quay.	0·0739	0·004	0·006	0·01

Gare Loch Water.

E.	Between Helensburgh Pier and Roseneath Point. Half distance.	0·03034	0·005	0·007	0·012
F.	Middle of loch off Barremman Pier.	0·0345	0·005	0·0035	0·0085
G.	Near Gare Loch Head - -	0·04138	0·0055	3·003	0·0085
	Average - -	0·0354	0·005	0·004	0·0097

Loch Long Water.

H.	Mouth of loch - - -	0·06373	0·005	0·004	0·009
I.	Between Cove and Blairmore Piers	0·02758	0·006	0·007	0·013
J.	Off Ardentinny - - -	0·0922	0·007	0·0035	0·0105
K.	Just below entrance to Loch Goil -	0·04475	0·006	0·0035	0·0095
L.	Half-way between Portincaple and Arrochar.	0·04755	0·007	0·005	0·012
M.	Head of loch - - -	0·028	0·004	0·006	0·01
	Average -	0·0506	0·006	0·005	0·011

Loch Goil Water.

—	Description of Sample.	Oxygen consumed per 100,000.	Free Ammonia per 100,000.	Albuminoid Ammonia per 100,000.	Total Ammonia per 100,000.
N.	Junction of Lochs Goil and Long -	0·04755	0·0025	0·008	0·0105
O.	Head of loch - - -	0·02234	0·004	0·0055	0·0095
	Average - -	0·035	0·0033	0·0067	0·010

Holy Loch Water.

P.	Entrance to loch - - -	0·06373	0·006	0·004	0·01
Q.	Near head of loch - - -	0·08695	0·005	0·004	0·009
	Average - -	0·075	0·0055	0·004	0·0095

Loch Striven Water.

R.	2½ miles up loch from entrance -	0·0207	0·004	0·004	0·008
S.	Head of loch - - -	0·01655	0·005	0·004	0·009
	Average - -	0·0186	0·0045	0·004	0·0085

Loch Ridan Water.

T.	Middle of loch - - -	0·01931	0·003	0·004	0·007

ANALYSES OF SCUMS.

Loch Goil.

Quality.	Mineral Matter. Per cent.	Organic Matter. Per cent.	Fatty Matters. Per cent.	Remarks.
Loch Goil - - No. 1.	69·65	30·35	1·75	Black and highly charged with sulphuretted hydrogen. Consisting of fine mud attached to sticks, shaw, leaves, seeds, fine ashes, smuts, and decomposing offensive organic matters.
Loch Goil - - No. 2.	64·29	35·71	1·3	Black, but only faint trace of sulphuretted hydrogen. Consisting of leaves, sticks, shells, small quantity of ashes and smuts, and other organic matter.
Loch Goil Head - No. 3.	52·76	47·24	2·5	Black and highly charged with sulphuretted hydrogen, and containing similar matters to No. 1, but with greater quantity of decomposing organic matter.

Loch Long.

Loch Long - No. 1.	61·35	38·65	1·8	Black. Containing cinders, smuts of carbon, seaweed, sticks, &c. No sulphuretted hydrogen.
Loch Long - No. 2.	69·41	30·59	1·55	Nearly black. Consisting of similar substances to No. 1. Also shells. No sulphuretted hydrogen.
Loch Long - No. 3.	74·46	25·54	1·85	Black. Containing considerable quantity of cinders and smuts; otherwise similar to above. Charged with sulphuretted hydrogen.

Loch Long.—Muds.

Description of Sample.	Sand. Per cent.	Fine Mud. Per cent.	Organic Matter. Per cent.	Nitrogen. Per cent.	Per cent. of Nitrogen in Organic Matter.	Remarks.	Number.
Mouth of Loch Long, on line between Cove Point and Stone Point, ⅓ distance from Cove Point.—18 f.	68·34	31·66	5·96	0·0476	·7997	Brown sandy mud -	16
Mud from same line as above, ⅔ from Cove Point.—32 f.	68·24	31·74	5·989	0·048	·8013	Brown sandy mud -	17
Mud from same line, ⅔ from Cove Point.—33 f.	51·65	48·35	8·258	0·07914	·9583	Dark fine mud, few stones only.	18
Mud from same line, ⅓ from Cove Point—25 f.	17·26	82·74	11·67	0·07836	·6714	Very fine smooth mud. High percentage of organic matter.	19
Middle of Loch Long, between Blairmore Pier and Cove Pier, ⅓ distance from Blairmore.—23 f.	35·14	64·86	10·04	0·0616	·6137	Fine mud, with a few stones.	20
Half-way between Blairmore and Cove Piers.—35 f.	75·82	24·18	5·62	0·09315	1·658	Black stinking sandy mud.	21
Between Blairmore and Cove Piers, ⅓ distance from Cove Pier.—18 f.	55·21	44·79	2·959	0·072	2·433	Dark smooth fine mud, no stones.	22
Claddie or Garletter, Bay ¼ mile from west shore.—8 f.	64·43	35·57	5·722	0·03868	·6759	Sandy brown mud -	23
Middle of loch, opposite Claddie Bay.—34 f.	44·03	55·97	9·412	0·0581	·6173	Fine brown mud, with sand and stones.	24
Middle of loch, 1 mile south of Ardentinny Point.—34 f.	12·8	87·2	13·74	0·098	·7132	Very fine smooth mud. High percentage of organic matter.	25
Middle of loch, off Ardentinny.—34 f.	19·36	80·64	13·34	0·1015	·7607	Very fine smooth mud. High percentage of nitrogen and organic matter.	26
Middle of loch, off Dornock. Very deep.—45 f.	12·28	87·72	14·17	0·1316	·9287	Fine smooth brown mud, with black stratum of fine matter on top of sample. High percentage of nitrogen and organic matter.	27
Middle of Loch, 1 mile south of Loch Goil mouth.—40 f.	17·4	82·6	14·72	0·1148	·7798	Fine smooth brown mud, with black deposit on top of sample.	28
Middle of loch, N.W. of Portincaple.—27 f.	90·718	9·282	2·926	0·0308	1·053	Chiefly sand - -	29
Middle of loch, 3 miles south of Arrochar.—34 f.	32·725	67·275	30·545	0·1551	·5078	Soft fine light mud, ½ nearly organic matter.	30
Middle of loch, 400 yards from head.—12 f.	13·47	86·53	15·31	0·1857	1·213	Fine smooth mud, with black deposit on top.	31

Loch Goil.—Muds.

Description of Sample.	Sand. Per cent.	Fine Mud. Per cent.	Organic Matter. Per cent.	Nitrogen. Per cent.	Per cent. of Nitrogen in Organic Matter.	Remarks.	Number.
Middle of loch, entrance off Corryn.—17 f.	17·28	82·72	14·34	0·1293	·9018	Fine smooth brown mud.	32
E. side of entrance, off Corryn.	25·9	74·1	9·022	0·0874	·9687	Very small sample -	33
Middle of loch, 2 miles above Carrick Castle.	20·623	79·377	19·295	0·1825	·9462	- - -	34
W. side of loch, 2 miles above Carrick Castle.	97·7	2·3	1·098	0·00467	·4249	Almost entirely composed of sand.	35
Loch Goil Head.—No. 1 -	17·68	82·32	16·39	0·1586	·9679	Fine smooth brown mud.	36
E. side of loch, 1¼ mile from head.	89·6	10·4	2·244	0·0214	·9759	Chiefly sand and shells, with slight black deposit on surface of sample. Smelling and containing H_2S.	37
W. side of loch, 1 mile from head.	75·84	24·16	5·023	0·0483	·9614	- - -	38
Loch Goil Head.—No. 2 -	98·22	1·78	0·918	0·00374	·4075	Entirely grey sand -	39

Holy Loch.—Muds.

Half-way across entrance of loch.	34·00	66·00	8·974	0·0841	·9371	- - - -	40
Top of Holy Loch -	19·73	80·27	12·64	0·1069	·8457	Fine smooth mud -	41

Clyde.—Muds.

Glasgow Harbour mud, as carried in barges and deposited in entrance to Loch Long, in 33 to 35 fathoms of water.	40·22	59·78	16·1	0·369	2·292	Black slimy stinking mud, containing a good deal of sand and stones, and a large quantity of organic matter.	1
Between Princes Pier, Greenock, and Roseneath Point.	20·65	79·35	12·93	0·091	·7037	Black slimy mud -	2
Gamekeeper's Bay -	5·449	94·551	12·45	0·1049	·8426	Black very fine slimy mud.	3
Between Gourock and Burren Point.	75·37	24·63	7·037	0·0033	·0469	Sandy mud - -	4
Between Hunter's Quay and the Clock Lighthouse, ⅓ distance from Hunter's Quay.	12·93	87·07	13·37	0·1082	·8091	Very fine brown mud. No stones or shells.	5

Gare Loch.—Muds.

Description of Sample.	Sand. Per cent.	Fine Mud. Per cent.	Organic Matter. Per cent.	Nitrogen. Per cent.	Per cent. of Nitrogen in Organic Matter.	Remarks.	Number.
Half-way between Helensburgh Pier and Roseneath Point.	26·83	73·17	9·541	0·079	·8281	Dark, slimy mud -	6
Washinghouse Bay, near Roseneath Castle, 400 yards from shore.	79·71	20·29	4·48	0·0315	·7031	- - - -	7
Entrance of loch, ¼ mile from Roseneath Castle, in a line towards Row.	89·78	10·22	3·056	0·0247	·8081	- - - -	8
Just outside loch. W. side Mull Bay.	90·05	9·95	2·88	0·0155	·5381	- - - -	9
Mouth of loch, in Narrow	All sand and shingle.	No trace of mud.	—	—	—	- - - -	10
Mouth of loch, off Barremman Pier.	20·61	79·39	14·85	0·1525	1·027	Very fine soft mud -	11
W. side, opposite Shandon Pier and Hydropathic Institution.	76·43	23·57	5·055	0·0296	·5856	- - - -	12
Middle of loch, off Faslane Bay. 1 mile from head.	20·32	79·68	14·79	0·1231	·8322	Fine smooth dark mud.	13
Half-mile from head of loch. 600 yards from shore, east side.	15·07	84·93	14·55	0·1367	·9396	Very fine grey smooth mud.	14
Head of loch. 600 yards from shore.	33·25	66·75	11·04	0·1559	1·412	- - - -	15

Loch Striven.—Muds.

2½ miles from mouth of loch.	16·01	83·99	13·17	0·1237	0·939	Fine mud, rather gritty.	42
Head of loch - -	19·93	80·07	12·4	0·1516	1·061	Fine mud, somewhat gritty.	43

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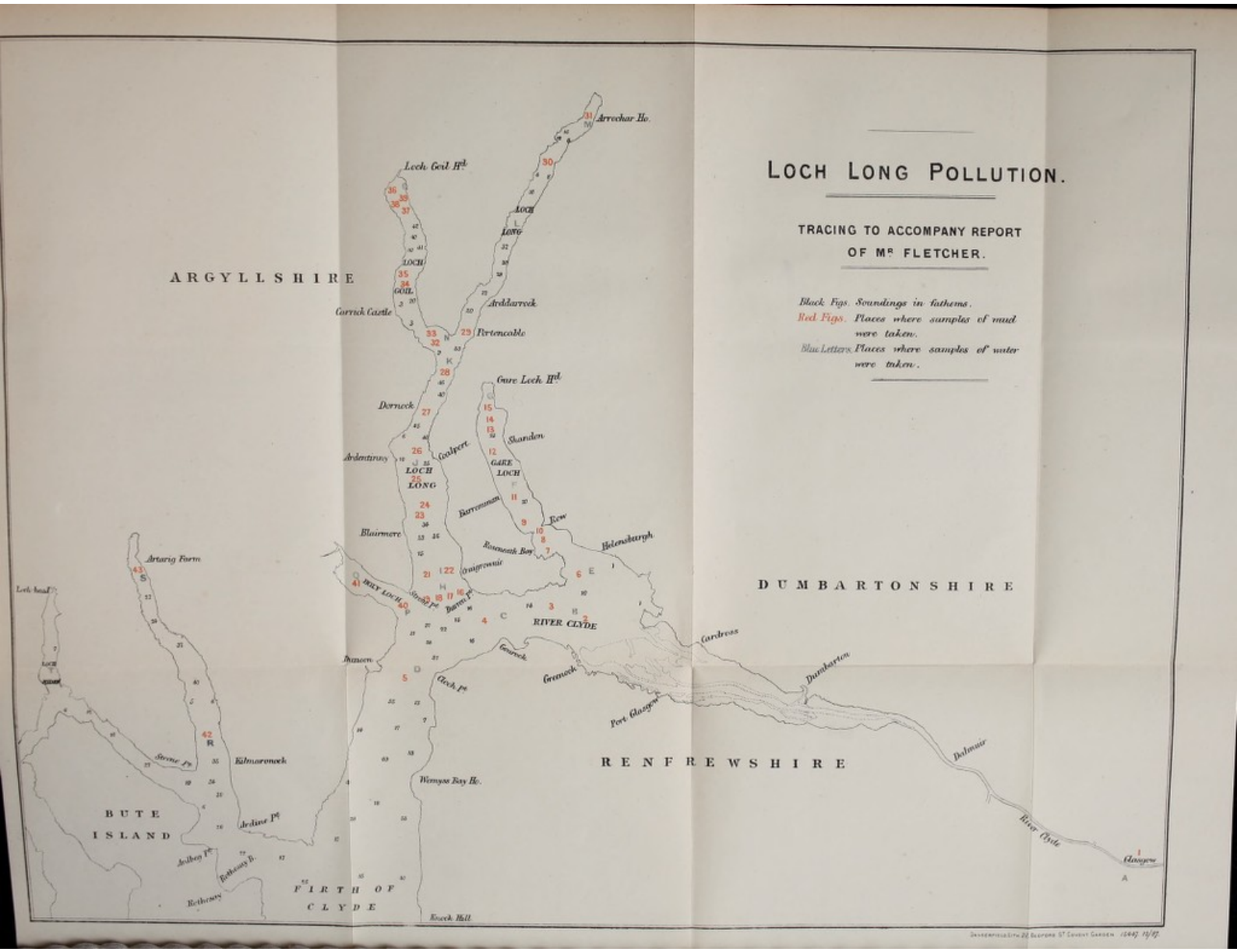
LOCH LONG POLLUTION.
TRACING TO ACCOMPANY REPORT OF Mr FLETCHER.
Black Figs. Soundings in fathoms.
Red Figs. Places where samples of mud were taken.
Blue Letters. Places where samples of water were taken.
ARGYLLSHIRE
DUMBARTONSHIRE
RENFREWSHIRE
BUTE ISLAND
FIRTH OF CLYDE
RIVER CLYDE
Arrochar Ho.
Loch Geil Hd.
LOCH LONG
Carrick Castle
Ardgarrock
Portencable
Gare Loch Hd.
Dornoch
Shandon
Ardentinny
Coulport
GARE LOCH
LOCH LONG
Blairmore
Rosneath Bay
Helensburgh
Craigrownie
Arturig Forte
Loch head
HOLY LOCH
Strone Pt.
Dunoon
Gourock
Greenock
Cardross
Dumbarton
Port Glasgow
Dalmuir
River Clyde
Glasgow
Kilmaronock
Wemyss Bay Ho.
Ardlamont Pt.
Ardbeg Pt.
Rothesay B.
Rothesay
Knock Hill