

CHAPTER XXX.

THE BASIN OF THE IRWELL, AND RIGHT BANK OF THE
MERSEY BELOW IT.*River Irwell.*

THIS important river is twenty-eight miles long, drains 311½ square miles, inhabited in 1801 by 253,327 inhabitants, in 1861, by 1,014,569. Of this area, 273½ miles consist of Carboniferous rocks, 107 Permian, and 28½ of Triassic Sandstone. Following its left bank from Flixton, it traverses the Upper Mottled Sandstone concealed by Drift. At Hulme Bridge it receives *Longford* Brook, rising west of Victoria Park, and flowing west through Croft and Davy Hulme. The Bridgewater Canal crosses the river opposite Barton-upon-Irwell, having previously crossed the *MERSEY* at Stretford. From the aqueduct the river flows past Trafford Park and Old Trafford, when it flows north-east over the Pebble Beds of the Bunter, between Old Trafford and Hulme. It receives *Corn* Brook, rising in the Glacial Drift overlying the Pebble Beds between Clayton, Openshaw, and Gorton, thence over the Manchester Coalfield fault, it traverses the *Spirorbis* Limestone, overlaid by the Permians of Ardwick, and drains the Glacial Drift overlying the Pebble Beds of Plymouth Grove, Chorlton-upon-Medlock, Green Heys, and Moss Side:—the latter contains 421 acres; population, 5403; rateable value, 82,000*l.*

River Medlock (tributary of Irwell).

OPENSHAW.—Acres, 579; population, 16,152; rateable value, 63,886*l.* Supply of this Authority and Moss Side from Manchester Corporation, where it receives the *Medlock*,

8 miles in length, which, with its tributaries, drains the larger part of Manchester. It leaves the Pebble Beds near Ancoats Hall, and traverses the Upper Coal Measures, by Beswick and Bradford, to the fault throwing in the Pebble Beds at Clayton Dingle. A boring has recently been carried out, and proved a great thickness of water-bearing Permian Sandstone. The Permians crop to the surface, between Clayton Bridge and Ashbridge Farm, where they overlie the Coal Measures; to the south is Droylsden and Fairfield. Eastward of the Permian boundary, the *Medlock* drains a large area of Coal Measures, the workable coals of the middle Coal Measures, coming in at Allthill, striking north and south; the eastern feeders traverse them to the Royley Mine, and cross the Lower Coal Measures, west of their rising, near the top of the Millstone Grit escarpment, overlooking the *Tame* valley.

Manchester Corporation supply:—BRADFORD, population, 16,113; rateable value, 33,814*l.* Droylsden, acres, 1144; population, 8679; rateable value, 25,000*l.*

The watershed dividing the *MERSEY* and its tributaries from the *Irwell* and its tributaries, commencing at the junction of the two rivers, ranges along the top of the bluff of Glacial deposits, on which are built the villages of Flixton, Urmston, Stretford, Chorlton-cum-Hardy, and Withington, where it no longer runs parallel to the river, but trends north-eastward by Birch Church, Victoria Park, and Fairfield, forming the northern margin of the *Gore* Brook Basin; thence by Ashton-under-Lyne, where it reaches the top of the steep escarpment formed by the base of the Lower Coal Measures and the Millstone Grit, running west of and parallel to the Pennine anticlinal, which ranges a little west of north as far as Old Delph, where it trends as much as 20° to the west of north through Friar Mere, which has the effect of cutting off the base of the Coal Measures, which the watershed has followed at White Slack, on the south side of Oden Edge, north of which streams draining west rise for the first time east of the fault. The watershed crosses

the fault, and traverses broken masses of Lower Millstone Grit rocks for $2\frac{1}{2}$ miles, until it joins the Pennine watershed, separating the Yorkshire rivers. This portion of the watershed runs along the top of the Millstone Grit escarpment, by Lussley, Mossley, Lidgate, and Besom Hill, at the head of Strine Dale by Badger Edge and High Moor.

The northern feeder of the *Medlock* drains the southern slope of the Oldham ridge and the Coal Measures area around Hollinwood and Merton; to the west these are overlaid by Permian Rocks and Pebble Beds, west of which it enters and eventually crosses the Manchester Coalfield.

OLDHAM.—*Acres*, 4665; population, 111,343; rateable value, 448,419*l.*, but township, 247,831*l.* more; constant supply of 3,000,000 gallons from tributaries of the River *Medlock* and River *Beal* (Lancashire) and River *Tame* (Yorkshire); Oldham Gaslight and Waterworks Companies Act, 1825, 6 Geo. IV. c. 171; ditto, 1838; 1 & 2 Vict. c. 96; Oldham Corporation Gas and Water Act, 1853, 16 & 17 Vict. c. 42; ditto, 1855, 18 & 19 Vict. c. 47; Oldham Borough Improvement Act, 1865, 28 & 29 Vict. c. 111; Oldham Corporation Waterworks Act, 1870, 33 & 34 Vict. c. 144; ditto, 39 & 39 Vict. c. 180.

The district south of Oldham, between the Chamber Colliery and Fitton Hill, drains into a tributary of the *Medlock*, impounded at Crime Water, which, flowing over the Permians south of Failsworth, joins the main stream at Clayton Bridge.

The watershed between the *Medlock* and the *Irk* ranges through Oldham, west of Hathershaw Hall, by Failsworth and along the Oldham and Manchester high-road, by Newton and Miles Platting, through the centre of Manchester.

FAILSWORTH.—*Acres*, 1073; population, 7907; rateable value, 29,264*l.*; supply constant from *Oldham Waterworks*.

MANCHESTER.—From the infall of the *Medlock* to that of the *Irk* the City of Manchester fronts on to the *Irwell* for $1\frac{1}{4}$ mile. It covers 4294 acres, and in 1871 had 351,189 inhabitants; in 1881 this number had fallen off nearly 10,000,

being 341,508. The rateable value is 2,225,050*l.* 8*s.* The supply is constant, and from 18 to 19 million gallons a day.* The works at Woodhead, in the valley of Longdendale, 20 miles from Manchester, were carried out under 10 & 11 Vict. c. 203, and 11 & 12 Vict. c. 101. The works can supply 25,000,000 gallons, which, with the present (1879) increasing yearly consumption, will only be sufficient nine years longer.

River Irk.

This stream falls into the *Irwell* near Victoria Station, and flows through a valley cut in the Glacial Drift, overlying the Pebble Beds for about a mile, and then over Permian Marls and Sandstones at Collyhurst, resting on the Coal Measures, at which point it receives *Morris* Brook, rising near Werneth Hall, Oldham, and flowing through Hollin-

* LIST OF TOWNSHIPS IN WHICH THE MANCHESTER CORPORATION SUPPLY WATER.

Manchester. Hulme. Chorlton-on-Medlock. Ardwick. Newton Heath. Cheetham. Broughton. Pendleton. Beswick. Bradford. Droylsden. Openshaw.	Gorton. Denton. Crumpsall. Haughton. Supplied in detail. Worsley. Barton-upon-Irwell. Eccles. Prestwich. Pendlebury. Flixton. Urmston.	Blackley. Burnage. Chorlton-cum-Hardy. Didsbury. Harpurhey. Levenshulme. Moss Side. Moston. Rusholme. Stretford. Withington.
SUPPLIED IN BULK TO LOCAL AUTHORITIES, WHO DISTRIBUTE IT IN THE FOLLOWING TOWNSHIPS.		
Salford. Bollington. Dunham Massey. Partington. Carrington. Ashton-upon-Mersey. Sale.	Northenden. Timperley. Bowdon. Altrincham. Hale. Ashley. Baguley.	Atherton. Tyldesley. Newton. Godley. Werneth. Hyde. Stockport (part of).

wood, Wrigley Head, Moston, and Newton Vale, where it traverses the Pebble Beds, the rest of its course being over the Coal Measures. This belt of New Red Sandstone is traversed by the *Irk* west of Harpurhey, from whence it trends westward with the strike of the rock, which it cuts across at Waterside, passing over a narrow strip of Permian on to the Coal Measures, which continue to the source of the river and its feeders at High Crompton, above Royton, and are covered by Drift, traversed by brooks draining the country around Blackley, Alkington, and west side of Oldham and Royton. Feeders on the right bank drain Thornham Fold and Middleton, which is partly on the main stream, Combershaw, and Heaton. Feeders on the Pebble Beds on the bank drain the district around Cheetham Hill, which is deeply covered with Glacial Drift down to the level of the *Irwell*, good sections being exposed at Higher Broughton.

MIDDLETON AND TONGE.—*Aeres*, 2323; population, 18,952; intermittent supply from Heywood Urban Sanitary Authority, who charge a very high rate, and give a short supply in time of drought; rateable value, 38,487*l.*

CHADDERTON.—*Aeres*, 3125; population, 16,897; rateable value, 66,000*l.*; nine-tenths of district in limits of Oldham Corporation Improvement Act, 1865 (28 & 29 Vict. c. 311); remaining tenth in that of Heywood Local Board Improvement Act.

CROMPTON.—*Aeres*, 2290; population, 9797; rateable value, 29,254*l.*; partly from Oldham Corporation and partly from springs.

ROYTON.—*Aeres*, 1210; population, 11,433; rateable value, 45,865*l.*; constant supply from Oldham Corporation; storage reservoir is required.

The *Irwell* valley, above the infall of the *Irk*, turns abruptly to the north-west, swinging in a series of long, loop-like curves from side to side of its alluvial plain; this general north-west direction is continued to Farnworth, and continued by its tributary, the *Tonge*, beyond Bolton, both streams in the

main running parallel to and on the downthrow side of a fault, which commences at Poynton, south of Stockport, in the Pebble Beds, ranges by Bramhall and Cheadle, where it brings up a tract of Permian, Withington, Salford, and Pendleton, north of which it throws the Pebble Beds on the east against the Middle Coal Measures on the west as far as Farnworth, after which, by Bolton and Little Bolton, it throws the Lower Coal Measures against the Middle Coal Measures; still further north, at Belmont, it throws the Kinderscout Grits of Anglezark Moors on the west against the Upper Millstone Grits. Here, also, the sources of the *Tonge*, impounded in the Belmont reservoir of the Bolton Waterworks, flow east of and parallel to the fault where it crosses into the *RIBBLE* watershed. The River *Roddlesworth* flows parallel to it as far as its infall into the *Darwen*.

Following the left bank of the *Irwell* past the cliffs of Glacial Drift at Higher Broughton, Castle Hill (an entrenched camp), to Kersall Hill, it receives *Singleton* Brook, draining Sedgley Park and Kersall Moor Racecourse. Other feeders, about 1½ mile in length, drain the Coal Measures of Prestwich, Hardmans Green, Pilkington, and Ringley, east of which the narrow outcrop of the Permian between the Coal Measures and the Pebble Beds, outcrops in the river; west of this the latter overlaps, first the Permian Marls, and then the Sandstones and the Coal Measures, thinning out against the fault at Farnworth.

PRESTWICH.—*Aeres*, 1917; population, 8627; rateable value, 2059*l.* 11*s.* 2*d.* (?); supply partly from *Manchester Waterworks* and partly from *Bury Waterworks*. Rainfall in 1879, at the reservoir, 347 feet above the sea, 34·32 inches; in 1880, 37·95 inches.

The *Irwell* valley at Farnworth turns at an angle of 30 degrees, and trends a little north of east as far as Radcliffe, where it receives the *Roch*, draining 62½ square miles. Following the left bank from the infall of the *Tonge* to that of the *Roch*, small streams drain the Drift-covered Coal Measures

of Outwood, Radcliffe Bridge, and WHITEFIELD or Stand. The latter has a population of 9516, rateable value of 33,373*l.* 7*s.* 6*d.*, and is supplied by *Bury Corporation Waterworks*.

River Roch.

The *Roch* traverses a valley cut for the most part in the sands of the Glacial Drift, resting on Middle Coal Measures as far as Duckworth Fold, where a north-west fault brings up the Gannister series, which continue by Harp Bridge and Heywood to Rochdale, between which points the river is crossed by a series of faults ranging about 35 degrees west of north, mostly with easterly downthrows, which counteract the south-west dip, and continually bring patches of the base of the Middle Coal Measures to the surface.

Whittle Brook, rising south of Heywood, and draining Birch, flows in at Hollins Vale, receiving *Black Brook*, draining Unsworth, at Thurston Fold. Higher up the river, east of Heywood, a feeder comes in rising on Castleton Moor; nearer Rochdale is the *Suddon Brook*, rising near the source of the *Irk*, west of High Crompton, and flowing past the south side of Rochdale. East of the borough is the infall of the *River Beal*, which drains an extensive tract of Lower Coal Measures around Milnrow, Butterworth, and Shaw. Its northern feeders rise near Greenacres, Oldham, and are bounded west by the watershed of the *Irk*. Its eastern feeders rise at the top of the Millstone Grit escarpment, overhanging the Upper *MERSEY* Basin, traversed by the anticlinal fault, except the feeder coming in at New Hey, which rises on the hills of Millstone Grit east of the fault, flowing through Culvert Clough, draining the wild country around Ogden and Helpet Edges.

HEYWOOD.—*Acre*s, 3200; population, Heywood Sanitary limits, in 1881, 23,050, Middleton and Tonge Sanitary limits, in 1881, 18,952; rateable value (Heywood), about 96,000*l.*; constant supply of 400,000 gallons and 250,000 to Middleton and Tonge; maximum supply about 1,200,000; under Hey-

wood Waterworks Act, 1846; Amendment Acts of 1855, 1866; Heywood Improvement Act, 1867; Heywood Waterworks Act, 1877. The impounding reservoirs are at Mayden Deane, in the township of Spotland.

ROCHDALE.—*Acre*s, 4180; population, 68,865; rateable value, 222,671*l.* 4*s.* 1*d.*; constant supply of 1,250,000 gallons from reservoirs storing from catchwater drains; works constructing, will be supplied from *Cowm* and *Springhull* Brooks; Rochdale Waterworks Act, 1866, and Improvement Act, 1872. Rainfall in 1879, at 473 feet above Ordnance Datum, 35.77 inches; in 1880, 37.96 inches.

MILNROW.—*Acre*s, 2000; population, in 1881, 7022; rateable value, 21,057*l.*; intermittent supply to one-third from Rochdale.

CASTLETON-BY-ROCHDALE.—Population, in 1881, 4017; rateable value, 2300*l.*; supplied by *Rochdale Corporation Waterworks*.

The *Roch* from Rochdale to its source south of Todmorden flows from north to south; near its head waters rise the Yorkshire and the Lancashire *Calders*. Following its right bank from its source past Littleborough and Smallbridge and Rochdale, it receives the *Spoddon*, rising south of Bacup, and flowing past Whitworth. The latter has 10,500 inhabitants; rateable value, 37,555*l.*; has a constant supply of 20 gallons a head from *Rochdale Waterworks*.

LITTLEBOROUGH.—*Acre*s, 2355; population, 10,405; rateable value, 33,000; constant supply from Rochdale.

West of the infall of the *Spoddon* several small streams drain the steep north bank of the *Roch*, by Chadwick, Bamford, and Birtle. West of the latter place, at Birtle Moor, is an exposure of the Rough Rock of the Millstone Grit, in which runs a subterranean watercourse or spring. A boring in this Grit is now in progress, at a site chosen by myself, above Messrs. Wrigley's reservoir impounding the stream flowing off the Moor, and a supply of underground water has been obtained. Other feeders drain the east side of Bury, and

the district lying between the *Roch* and the *Irwell*, called Red Vales.

Following the left bank of the *Irwell* from Red Vale, it traverses the Middle Coal Measures by Bury south of Walmersley, entering the Lower Coal Measures.

BURY.—Population, 51,582; constant supply of 90,000 gallons per hour from reservoir, storing water flowing by gravitation from moors and other lands; Bury and Radcliffe Waterworks Acts, 1853, 1858; Haslingden and Rawtenstall Waterworks Acts, 1853, 1856, and 1858; Bury Improvement Act, 1872.

Bury Waterworks supply the following with water from a reservoir in the township of Dunnockshaw at Clow Bridge, collecting surface water off cultivated land. Drainage of several houses, and water pumped from a coal-mine where 30 men are employed, finds its way to the reservoir; the water is not filtered; under Haslingden and Rawtenstall Waterworks Act, and the Bury Improvement Act, 1872:—RAWTENSTALL, *acres*, 1667; population, in 1881, 12,571; rateable value, 38,127*l.*; supply intermittent. Haslingden, *acres*, 3627; population, in 1881, 14,333; rateable value, 44,818*l.*; supply intermittent.

Following the left bank of the *Irwell* from Bury north, it crosses a north-west fault bringing in the Millstone Grits at Walmersley, through which it has cut a deep and wide valley, by Summerseat, Ramsbottom, Edenfield, and Rawtenstall; numerous feeders with steep fells come down from the hills above at Harden Moor, Whittle Hill, and Coupe Lowe. The beds of Millstone Grit lie very flat in this group of valleys, Third Grits occupying the bottom of the principal valleys, Shales and Second Grits occurring higher up, and the Rough Rock, or the Lower Coal Measures, capping the hills, which form the remarkable group of valleys of denudation, the eastern portion of which is known as the Forest of Rossendale.

BACUP.—Population, 25,033; rateable value, 83,017*l.*;

constant supply, except in drought, from *Rossendale Waterworks*, who supply one-third of the district from their reservoir; Rossendale Waterworks Act, 1853, Amendment Act, 1854, 17 Vict. c. 18; the Company should be compelled to filter the water, and have not the means of supplying the whole of the district within their limits of supply. Rainfall in 1879, at Calf Hey, 800 feet above the sea, 54·75 inches; in 1880, 46·10 inches.

A strong feeder, rising at the top of the Millstone Grit at Hopton Park, drains Higher Booth, Goodshaw, and Lower Booth, and falls into the *Irwell* at Rawtenstall. West of this valley a tongue of high ground capped with Rough Rock forms Cribden Moor, on the western slope of which are the well-known quarries in the Haslingden Flags or Second Millstone Grit, which gives the name to this horizon of the Grit. Between the Rough Rock and the Flags is a bed of Shale, and another bed underlies the Flags. Between Haslingden and Cribden Moors in the Haslingden valley, drained by *Swindel* Brook, which receives on its right *Mill* River rising under Pike Low, the stream is impounded above Holder's Wood. Another feeder drains Musbury valley, on the heights of which are large Flag quarries; the united stream falls into the *Irwell* at Tottington High End. Further south the right bank of the *Irwell* drains the hills above Holcombe and Rawtenstall, and receives *Holcombe* Brook, rising in the cliff of Rough Rock known as the "Ratchers,"* at Bull Hill, which is traversed by the watershed separating the *Upper Irwell* basin from that of *Bradshaw* Brook, tributary to the *Tonge*.

Numerous tributaries drain the Drift-covered Coal Measures occupying the right bank of the *Irwell*, around Tottington, Elton, Ainsworth, Radcliffe, Bradley Fold, and Little Lever, south of which place the *Irwell* receives the River *Tonge*.

* Professor Hull, M.A., F.R.S., 'Memoir on the Geology of Bolton,' in 'Memoirs of the Geological Survey.'

RADCLIFFE.—*Aeres*, 2300; population, 16,263; rateable value 71,402*l.*; constant supply from *Bury Corporation Waterworks*.

LITTLE LEVER.—*Aeres*, 809; population, 4413; rateable value, 18,215*l.*; intermittent supply from Bury; high service reservoirs and larger mains required.

River Tonge.

This stream drains entirely a Coal Measure and Millstone Grit area. Following its left bank to its source, it flows over Middle Coal Measures to beyond Bolton. Just below that town it receives *Bradshaw Brook*, which runs nearly parallel to it, draining the county round Turton, Entwistle, Bradshaw, Harwood, and Tonge, rising on the outliers of Millstone Grit and Gannister, south of Over Darwen. At Entwistle it is embanked for *Bolton Waterworks*.

TURTON.—*Aeres*, 4613; population, 5653; rateable value, 21,104*l.*; supply from Bolton Corporation, under Bolton Improvement Act, 1850, and wells.

The *Tonge*, north of the infall of the brook, drains the Middle Coal Measures as far as Astley Bridge, where its direction is continued by the *River Eagle*. At Eagley Bridge this stream enters the Millstone Grit, flowing past Walmsley and Belmont, between which and Longworth is the Bolton Corporation reservoir.

The dip of the Millstone Grit is westerly on both sides of the fault traversing the valley. The watershed at the col at the northern end of the valley is 968 feet above the mean level, rising to 1215 at Bromley Pastures, and 1450 at Winter Hill.

River Croal.

At Astley Bridge the *Tonge* turns westward, crossing the Bolton and Pendleton fault between Sharples and Halliwell. Parallel with this stream flows an important tributary, the *River Croal*, rising at Red Moss below the Rivington reservoirs,

which is traversed by the watershed dividing the basin of the *Douglas* flowing into the estuary of the *RIBBLE* from that of the *MERSEY*. From the surplus waters of this Moss rise the *DOUGLAS* and *Middle Brook*, the head waters of the *Croal*, on its southern margin. The *Croal* flows through a broad valley in the strike of the Coal Measures nearly corresponding to the division between the lower and upper divisions of these Measures. It has been filled up with deposits of Glacial Drift, Sand, and Gravels overlaid by Boulder Clay, which have to a great extent been re-excavated. These sands are valuable in storing up the water they absorb during heavy rains, and delivering them gradually in times of drought.

In the quarries in the Rough Rock, on the hill above Horwich, strong feeders of water were met with, which are abstracted by a syphon for the garden of an adjacent house.

The watershed between the *DOUGLAS* and *Middle Brook* at the highest part of the Peat Moss is 367 feet above the mean sea-level; from Red Moss it ascends Blackrod Hill, reaching 466 feet at Highfield House, when it trends northward, and is joined by the watershed separating the *Croal* valley waters from tributaries of the *MERSEY* flowing south of Leigh and Hindley. The watershed bounding the *Croal* valley follows the crest of the hill from Blackrod, by Wingates, to West Houghton, along which was carried a Roman road, thence eastwards between Dean and Little Hulton, rising to 550 feet at Top Caw. From this point the *Croal* watershed trends north-east past Rumworth to the infall of the river into the *Tonge* at Bolton.

BOLTON.—*Aeres*, 1162; population, 105,422 (of water limits outside borough, 64,408?); two service reservoirs; four storage reservoirs; Belmont gathering-grounds in townships of Sharples, Longworth, and Entwistle, Bradshaw in township of Turton; constant supply of 2,625,000 gallons in the borough; 1,875,000 outside; rateable value, Borough 361,000*l.*; outside water limits (roughly) 313,000*l.*; works carried out under Bolton Improvement Acts, 1854, 1864, and 1865; filtering beds are required.

ANNUAL AMOUNT of RAIN and EVAPORATION at BOLTON, during the 50 years ending Dec. 31st, 1880 (from the register of H. H. WATSON, Esq., F.C.S., &c.), at the FOLDS, 286 feet above the sea.

	Rain.	Evapo.		Rain.	Evapo.
	Inches.	Inches.		Inches.	Inches.
1831	62·30	22·07	1856	49·23	20·03
1832	53·77	22·35	1857	40·19	22·52
1833	51·70	24·23	1858	41·02	22·21
1834	43·98	24·18	1859	46·02	18·99
1835	46·44	23·78	1860	57·66	21·94
1836	53·78	24·36	1861	44·91	19·45
1837	42·25	17·12	1862	53·43	17·80
1838	47·85	20·16	1863	53·75	19·04
1839	45·26	24·71	1864	42·74	20·31
1840	45·03	23·79	1865	37·51	20·24
1841	53·87	24·51	1866	59·20	19·03
1842	38·63	24·69	1867	45·27	18·88
1843	49·40	24·02	1868	46·34	23·41
1844	34·63	22·60	1869	49·00	19·24
1845	48·11	23·39	1870	43·47	18·92
1846	40·82	24·16	1871	40·93	18·52
1847	52·32	22·76	1872	57·59	17·84
1848	54·05	22·02	1873	42·69	18·21
1849	47·77	26·21	1874	48·67	18·59
1850	47·99	29·23	1875	43·94	18·94
1851	41·89	26·40	1876	46·10	20·09
1852	55·19	35·93	1877	60·33	15·97
1853	36·88	23·85	1878	45·79	18·95
1854	45·46	21·17	1879	42·82	24·60
1855	36·19	17·86	1880	43·36	19·72

The mean of 49 years, ending 1879, was 42·82 inches, and the mean evaporation 24·64 inches.

RAINFALL at BOLTON WATERWORKS, taken by Mr. R. H. SWINDLEHURST in 1880.

	Belmont, 800 feet.	Heaton, 500 feet.	Entwistle, 700 feet.
	58·20	41·80	53·50

The mean fall at Belmont for 38 years ending 1880 was 56·26 inches. Mean fall at Heaton for 22 years was 44·37 inches. Mean fall at Entwistle for 13 years ending 1880 was 54·85 inches.

ASTLEY BRIDGE.—Acre, 1162; population, 5614; rate-

able value, 23,777*l.*; supply from Bolton, constant, under 7 Vict. c. 74.

LITTLE HULTON.—Acre, 1706; population, 5724; rateable value, 22,610*l.* 18*s.* 9*d.*; constant supply of 100,000 gallons from Bolton, under their Corporation Act, 1872.

The remaining tract of country in the *Irwell* Basin undescribed is bounded to the west by the watershed of the *MERSEY*, which ranges south-east from Top of Caw to Little Hulton, from which it runs south down the dip of the Middle Coal Measures, by Ellenbrook, crossing the Permian outcrop east of Astley Green it enters the drift-covered plain, resting on the Pebble Beds and surmounted by Chat Moss, which it crosses south-westward to Olive Mount, then south-eastward to Lower Islam, where it falls into the junction of the *Irwell* with the *MERSEY*.

Following the right bank of the *Tonge*, from Bolton, it flows past Great Lever and Darley Hall to Farnworth, where it falls into the *Irwell*, which thence assumes its direction, flowing parallel with the Great Bolton fault on its downcast side. There can be little doubt the direction of the stream is governed by the fault; the rock is only seen in the bed of the stream, the valley above being entirely excavated in Glacial Drift. The strike of the rocks on both sides of the fault is east-south-east, the base of the Gannister series intersecting the fault at Bolton Moors, that of the Middle Coal Measures at Moses Gate, the outcrop of the Rams and Brassy Mines at Clifton, that of the Worsley 4-foot coal between that place and Pendlebury, the Permian at Pendleton, the river side of which is on the Pebble Beds, which rest directly in this district on the Permians, the Lower Mottled Sandstone being absent.

FARNWORTH.—Population, 20,701; rateable value, 59,500*l.*; supplied from *Bolton Corporation Waterworks*, under Bolton Improvement Act, 1850.

KEARSLEY.—Population, 7241; rateable value, 20,095*l.*; constant supply from Bolton Corporation.

SWINTON and PENDLEBURY.—Acre, 2165; population,

in 1881, 18,108; rateable value, 66,907*l.*; constant supply from Manchester.

SALFORD.—*Acres*, 1329; population, 176,233; rateable value, 372,218*l.* 10*s.*; (Salford District) constant supply of 1,840,000 gallons from Manchester Corporation, who are bound to supply Salford Corporation in bulk with quantity not exceeding 2,000,000 gallons a day; Broughton and Pendleton are parts of the Borough of Salford, but are supplied by Manchester direct.

A minor watershed ranges from Little Hulton, by Moss Side, Clifton Moss, Newtown, and Pendlebury, separating the tributaries of the *Irwell*, flowing in above the turn of the river at Salford, from those coming in to the south, which flow first over the Coal Measures of Newtown, Roe Green, Swinton, and Worsley, and then over the Pebble Beds capped by Glacial Drift of Eccles, Monton, Hazelhurst Green, Patricroft, and Barton, then over the Upper Mottled Sandstone at High Islam, where the edge of the Chat Moss advances to no great distance from the valley margin.

Rainfall at Eccles Observatory, 137 feet above the sea:—

1876 38·35 | 1877 45·17

Mr. Mackereth, F.R.A.S., states the average rainfall of Eccles to be 36·03 inches for 17 years, ending 1877.

At Barton the Bridgewater Canal crosses the *Irwell*, from which it is carried to Worsley, and thence westwards, skirting the northern edge of Chat Moss, to Leigh. Population of BARTON, Eccles, Winton and Monton, 21,785.

Between High and Low Islam the surface of the rock is beneath the river-bed, and the banks or bluffs of the valley are formed entirely of Glacial Drift, the two Boulder Clays being separated by the Middle Sands overlying the Upper Boulder Clay.

RIVER MERSEY—*Right Bank.*

Following the right bank from the infall of the *Irwell* at Lower Islam, the river crosses the base of the Lower Keuper

Sandstone. The best sections, showing coarse beds, are seen on the opposite side of the river at Partington. At Cadishead they are obscured by Boulder Clay. Keuper Sandstones are, however, visible in the remarkable valley of *Glazebrook*, which falls into the *MERSEY* at Hollinfare. It is cut in Glacial Drift resting on rock, and is capped by the peat of Chat Moss on both sides, once evidently continuous, and the disruption is stated to be of no great antiquity. It drains an area of not less than 70 square miles, of which the northern 49 consist of Drift-covered Middle Coal Measures, and the southern of 21 miles of Permian Sandstone and Marls, and at West Leigh and Astley, of Pebble Beds and Upper Mottled Sandstone. The latter is Drift-covered, and capped with the peat of Chat Moss, Holcroft Moss, and Glazebrook Moss; the only permeable beds therefore being the Permian and Pebble-Bed Sandstone, fringing the southern margin of the Coalfield. The northern feeder rises on the Haigh and Blackwood watershed at a height of little less than 500 feet, then, flowing through Scot Lane valley and the Drift gorge of *Borsden* Brook, descends to 240 feet at Hindley Vale, to 150 feet at Hindley, thence to Platt Bridge at 96 feet, and under the Wigan and Leigh Canal at Bamfurlong, where it trends eastwards and follows the strike of the Pebble Beds, passing south of Leigh, as *Plank Lane* Brook, to Hawkhurst, where it receives the Leigh and Tyldesley feeder, *Hindford* Brook, from the north and *Shaw* Brook from the east, traversing the strike valley from the opposite direction to *Plank Lane* Brook, and like it flowing along the boundary of the Pebble Beds and Upper Mottled Sandstone, which latter, as before stated, is Drift-covered.

Another Coal Measure feeder rises near the *Croal* watershed at Wingates, 455 feet above the sea, flows by West Houghton, Fickley Green, and West Leigh, and falls into *Plank Lane* Brook. *Hindsforth* Brook rises under Top of Caw, 550 feet above the sea, and flows by Middle Hulton, Tyldesley, at 130 feet, with a feeder from Atherton, and Leigh, Bedford, south of which it joins the two streams already mentioned.

The country around Little Hulton, Peel, Ellenbrook, and Astley drains into *Shaw* Brook.

These three brooks, draining 49 square miles of country consisting of strata in the main of an impermeable character, and further overlaid by impermeable beds of Boulder Clay, receive an annual rainfall of at least 40 inches, which, considering the sharp gradients of the upper part of the district, must flow off rapidly, and allow little time for evaporation. In such a district, half the fall may fairly be expected to run off, or 20 inches per annum, which would give a daily average of 800,000 gallons per square mile, or 39,250,000 gallons a day for the drainage area, or, with a run-off of only 10 inches, a daily average of 19,500,000 gallons, or 28,000,000 gallons for the entire drainage area. No such quantity is discharged by *Glaze* Brook, and it is interesting to inquire where the water is abstracted.

The drainage of the Coal Measure tract is discharged at Abram, West Leigh, and Astley respectively, into a brook running over the Pebble Beds of the Bunter, which are but little covered with Glacial Drift, and are of an exceedingly porous character. The dip is southerly, and the Coal Measures have been proved at Winwick and Parkside to underlie them at no great depth. The southerly dip continues on the Cheshire side of the river, bringing in successively the Lower Keuper building stones, the Waterstones, and the Keuper Marls, which latter occupy a deep basin, the centre of which is under Northwich, the Lower Keuper and Bunter Beds reappearing on the Market Drayton and Whitmore side of the basin. These sandstones will be fully charged with water under the whole of this basin, beneath the salt-bearing Marls. In times of excessive rainfall the water-level in the rock near the outcrop will be raised, and at such times will be above the plane at which it is crossed by the *MERSEY*, in which case surplus waters will issue as springs in the bed of the *MERSEY*. This water will have slowly filtered through the rock underlying the Glacial Drift beneath Chat Moss. The excess of rainfall that the mosses cannot absorb will exude

on their edges in all directions, that issuing on their northern margin will flow into the stream to the north, be partly absorbed, and carried back southwards in the rock beneath, the overflow finding its way into the bed of the *MERSEY*, the remainder to the stores accumulating under the Cheshire Saltfield.

Bryn Moss, on the watershed between the basin of the *DOUGLAS* and the *Borsden* Brook basin, has only an elevation of 102 feet. The valley, in which is Bryn Moss and other adjoining mosses, slopes almost imperceptibly in both directions, and must be regarded as the natural head of the *DOUGLAS* Valley, rather than the narrow gorge in which the *DOUGLAS* flows, entering the main valley on the east side of Wigan. If this view be correct, the Bryn Moss Valley must have been excavated by a stream occupying the Black Lane Valley, and flowing from the east, receiving first the *Borsden* Brook waters and then those of the *DOUGLAS* above Wigan. That this was the case in pre-Glacial times there can be little doubt, and it probably flowed from Astley Green, at the epoch preceding the growth of the peat mosses.

Looking to the great depth of the valley of the *DOUGLAS* between Ashurst Beacon and Harrock Edge, it is probable that the pre-Glacial *DOUGLAS* rose at a very considerable elevation, which would be the case if the *Irwell* at that period was not a tributary to the *MERSEY*, but continued its trend from Old Trafford to Eccles and Patricroft, into the Plank Lane, Bryn Moss, and *DOUGLAS* Valley, following the line taken by the projectors of the Wigan and Leigh Branch of the Bridgewater Canal.

WEST HOUGHTON.—*Acres*, 4341; population, 9197; intermittent supply from Bolton Corporation at 6*d.* per 1000 gallons, delivered at township boundary; rateable value, 36,728*l.*

HINDLEY.—*Acres*, 3611; population, 14,667; rateable value, 49,403*l.*; constant supply of 68,152 gallons from Bolton Corporation, by agreement for five years, under Leigh and Hindley Water Act, 1876.

ATHERTON.—*Acres*, 2426; population, in 1881, 12,602; rateable value, 40,000*l.*; supply of 1,000,000 gallons per week from Manchester (maximum supply of 1,450,000 gallons), through Tyldesley; Public Health Act, 1848.

TYLDESLEY with SHACKERLEY.—*Acres*, 2489; population, 9953; rateable value, 40,949*l.*; supply from Manchester of 350,000 to 500,000 gallons, including that supplied to Atherton.

LEIGH.—*Acres*, 6191; population, 21,733; rateable value, 65,064*l.*; water supply from Atherton Local Board by agreement for 7 years, from the 1st of January, 1876, and from Bolton Corporation by agreement for 6 years, from the 1st of March, 1877; Public Health Act, 1875, and Leigh and Hindley Local Board Water, 1874.

Between the infall of the *Glaze* Brook and Hollinfare the river crosses the Rosthern and Warburton fault, which, in the Wigan Coalfield, becomes the Great Standish fault, with an easterly downthrow. West of it, to Warrington, the valley runs through the top beds of the Upper Mottled Sandstone, which does not appear to crop in the river bed. The Upper and Lower Boulder Clay, separated by the Middle Sand, are seen in the valley banks by Martinscroft Green, Woolston, and Poulton. To the north, Risley, Woolston, and Rixton Mosses cover several square miles, the peat resting on the Shirdley Hill Sands, which more or less overlie the Boulder Clay at Padgate and Croft. West of the latter the Pebble Beds come to the surface, and are drained by *Kenyon* Brook, flowing by Orford Green, where it is known as *Black* Brook.

WARRINGTON.—*Acres*, 5042; population, 41,456; rateable value (Borough), 146,976*l.* 18*s.*; constant supply of 800,000 gallons from Water Company, who have two distinct sources of supply: (a) reservoir of 16 acres at Appleton, in Cheshire, storing the surface waters flowing off about 1360 acres of cultivated land; (b) covered reservoir at Winwick, north of Warrington, storing water pumped from artesian wells in the Pebble Beds, at which works are still being carried out.

The Waterworks Companies Acts of 1840, 1849, 1855, 1868, and 1878. Rainfall at Friar's Green, Tocon Hall, 33 feet above the sea:—

1878.	1879.	1880.
34·25	30·68	34·34

In boring at Winwick the deposits penetrated by Mr. Timmins were: Drift, 30 feet; New Red Sandstone, 310½ feet; Upper Coal Measure, Marls and Sandstone, 33½ feet; Limestones and Marls, 37 feet (Ardwick Beds).

The dip of the Pebble Beds in the neighbourhood is to the south-east and south, at low angles. In Nos. 1 and 2 shafts the strata consist of soft red moulding sand without pebbles, very easily worked. No. 3 shaft exhibits characteristic Pebble Beds, the current planes being covered with dark mica; the rock is hard, and contains pebbles. No. 4 shaft, near the Spa Well, also is in undoubted Pebble Beds, though moderately hard, but contains many pebbles.

A drift, or level, is being driven to this shaft from the pumping station 1200 yards distant, which will doubtless throw much light on the structure of these Sandstones. A powerful spring of water was met with in No. 4 shaft, at a depth of about 90 feet from the surface.

The level of the Parkside wells of the North-Western Railway will be about 110 feet, that of Winwick pumping station 125 feet, that of the Spa Well about 96 feet, that of the Dallam Lane Forge well about 43 feet. Between Golborne and Parkside the Pebble Beds occur, dipping east; from Parkside to Spa Well they continue, but gradually change their direction of dip to south-east, as is well seen at Middleton Hall Quarry, near Spa Well. Had not this change of strike taken place the base of the Pebble Beds would have cropped out north of Winwick, instead of which they occupy a considerable tract around Golborne, and the thickness of Triassic strata at Parkside would have been much less than at Winwick, 1¼ mile to the south, the strike

of the rocks nearly coinciding in direction with a line drawn between the two wells.

Between the Winwick pumping station and Dallam Lane Forge, $2\frac{1}{2}$ miles distant, this is not the case; the Pebble Beds at Hulme Delf, south of Winwick, dip south, or directly at the Dallam works. The dip varies at different quarries from 4° to 8° . Taking it at 4° , and the base of the Trias at Winwick at 215 feet below Ordnance Datum, and assuming the surface of the Coal Measures beneath the Trias to correspond to the amount of dip, the base of the Trias could be carried down 1000 feet at Dallam Lane Forge, or 1215 feet below Ordnance Datum, and 1258 feet below the surface.

The boring at Dallam Lane actually penetrated of this depth 880 feet, the lowest beds met with being 70 feet of soft Lower Mottled Sandstone, with the millet-seed grain, occurring immediately beneath (pebble-bearing) Pebble Beds, so that these soft beds evidently belong to the uppermost portion of the Lower Mottled series. These at Winwick reach a thickness of more than 200 feet, and at Bootle boring of more than 300 feet, in the latter case without their base having been reached, so that they may possibly be 350 feet thick under Warrington, in which case their base will be 1230 feet beneath Dallam Lane Forge, which closely agrees with the calculation of the probable position of the base of the Trias, based upon the observed dips at Winwick. There is therefore strong evidence to believe that the Coal Measures underlie Warrington at a depth of 400 yards, but at what angle and in what direction they dip there is no evidence to show. The highest coals of the Wigan Coalfield, the "Ince Mines," are striking nearly south, between Town Green, Ashton, and Edge Green, Golborne, and, did no fault intervene, their southern prolongation would pass through Newton Bridge and Great Sankey, but it is repeatedly thrown back westwards by faults, with westerly downthrows, so that the Coal Measures between Winwick and Sutton are entirely

measures lying above the Lyons Delf of St. Helen's, and probably in great part belong to the Upper or Manchester Coalfield. In the centre of this tract a colliery has been sunk at Bold Moss, east of St. Helen's Junction, and several coal-seams have been passed through. These have been supposed to be identical with the upper seams of the St. Helen's field; but, after comparing the section drawn to scale with the neighbouring collieries, I am inclined to think that these coals are on a higher horizon, and probably belong to the Upper Coal Measures. Progressing westwards, the first fault with an easterly downthrow is that passing through Whiston, which, with that passing Sutton Heath, throws in the remarkable trough of New Red Sandstone, extending from Rainhill to Eccleston Hill, and it will be noted that it is in this triangle that the small tract of Upper Coal Measure Limestone is brought by faults to the surface at Huyton, with the normal north-east and south-west strike.

Sankey Brook.

The *MERSEY*, after making two sharp turns past Warrington, receives the drainage of *Sankey Brook*. Following its left bank, up stream, through a shallow valley in the Boulder Clay more or less covered with Shirdley Hill Sand, it receives *Spa Brook*, which rises at Spa Well at Arbury on the Pebble Beds, and falls into the main stream at Hulme. Between Winwick and Wargreave is the infall of *Newton Brook*, which, after receiving a feeder from St. Oswald's Well, trends north past Newton-le-Willows (Newton Bridge Station and North-Western Railway) to Golborne Park, where it is impounded in Golborne Dale. The western feeder of *Newton Brook* rises near Haydock Lodge; an eastern feeder followed up stream, after twice crossing under the railway, trends north-westward by Golborne and Ashton-in-Makerfield, as *Mullingford Brook*; crossing the Great Pemberton fault, it enters the Wigan Coalfield, and, flowing past Downall Green, rises on the eastern slope of Billinge village hill.

The Haydock Lodge stream receives a feeder draining the

Coal Measure country around Haydock, which is covered with thick deposit of Glacial Drift.

West of the infall of *Newton Brook*, *Sankey Brook* skirts Newton Common and Racecourse, and soon after passes on to the Coal Measures. An important feeder comes in on the left bank, one branch of which rises on the west side of Billinge Beacon, traversing the Gannister series, which are extensively worked for flags, crosses the Billinge fault throwing in the middle Coal Measures, and is impounded at Caw Mill Dam. The other branch rises in the extreme north-western corner of the *MERSEY* watershed, at Bickerstaffe east of Ormskirk, flowing past Rainford and the northern side of St. Helen's. At Rainford good sections are exposed of a deep red-coloured fine-grained current-bedded sandstone, referred by Mr. Binney to the Permian, and by Professor Hull to the Lower Mottled Sandstone; *Windle Brook* rises in it.

ST. HELEN'S.—*Acre*s, 12,078; population, 57,234; rateable value, 211,642*l.*; constant supply from wells in Pebble Beds at Eccleston Hill, and Lower Mottled Sandstone at Whiston, supply 1,750,000 gallons of water daily, stored in two covered service reservoirs. A small supply of water, used for trade purposes, is derived from surface drainage, total supply available, 2,000,000 gallons; works under St. Helen's Improvement Acts, 1851, 1855, 1869, and Public Health Act, 1875.

Strong feeders of water occur at Bold Hall and Collins Green collieries, water from the latter is used as a supplemental water supply for St. Helen's. The Sankey Canal is carried on the right bank of *Phipp's Brook* from St. Helen's, and has its outlet at Fiddler's Ferry. Following the *MERSEY* watershed from Bryn Moss, it crosses the Middle Coal Measures to the Gannister beds of Billinge Beacon, and runs along their strike to near Pimbo Lane, then trends westward, and descends to 272 feet near the source of the River *Tawd*, to 240 feet at Causeway Moss near Blaguegate, and 232 feet at Four Lane End, Bickerstaffe, where the watershed turns and trends southward, still further descend-

ing, being 200 feet at Bickerstaffe Wood, 150 feet at Rainford Station, which level is continued in Barrow Nook Moss, from which the watershed begins again to ascend, being 185 feet at Massborough Hall and 264 at Knowsley Chase.

BILLINGE.—*Acre*s, 4591; population, 3882; rateable value, 15,702*l.* 17*s.* 4*d.*; scheme sanctioned by Local Government Board, to yield 20 gallons per head, but no provision is made for any great increase of population; Public Health Act, 1875.

ASHTON-IN-MAKERFIELD.—*Acre*s, 6249; population, 9825; rateable value, 52,414*l.*; works constructing under Ashton Local Board Act, 1875; constant supply of 180,000 gallons from reservoirs storing water off cultivated land; wells in New Red Sandstone.

HAYDOCK.—Population, 5863; wells and tanks; rateable value, 19,335*l.* 2*s.*

NEWTON-IN-MAKERFIELD.—*Acre*s, 3103; population, 10,580; rateable value (for water purposes), 24,380*l.*; supply constant of 46,000 gallons from London and North-Western Railway Company, supplied by meter to sanitary authority; Local Government Act, 1858; Newton Improvement Act, 1855.

Sankey Brook drains 62 square miles, of which 36 consist of Coal Measures largely overlaid by Glacial Drift, and 25½ of New Red Sandstone and Permian Sandstone occurring on three sides of the Coal Measure area. Taking 30½ miles of the former and 5½ of the latter as impermeable, there would be a total of 36 miles on which all water would be thrown off. Taking the rainfall at 36 inches per annum and evaporation at 16, a balance of 20 inches per annum would be run off, or 800,000 gallons per day per square mile, or a daily run-off, due to the Coal Measures, of nearly 37,000,000 gallons. A large portion of this volume is absorbed by the Pebble Beds over which these streams fall, which absorb in this area not less than 20 inches of the annual rainfall.

Bold Park and Fairs Green are drained by two feeders uniting and forming *Whittle Brook*, flowing past Great Sankey, and falling into the *MERSEY* at the infall of *Sankey*

Brook. At Penketh another feeder comes in, *Haltons Brook*. Between this brook and Widnes is the district of Cuerdly, which is drift-covered, but at Farnworth, Cronton, Appleton, Widnes, and Ditton several exposures of Pebble Beds crop to the surface, and numerous small wells prove the permanent water-level in the rock to rise to 50 feet above the mean level of the sea.

At Runcorn the two sides of the valley contract to form Runcorn Gap, only a quarter of a mile in width, with rock on both sides. Mr. Mellard Reade has pointed out that borings made on the Lancashire side prove the rock to suddenly sink on the north side 141 feet, through which depression, since filled up with Glacial Drift, he believes the river to have run in pre-Glacial times.

A remarkable tract of New Red Sandstone is intruded by faults, between the Coal Measures of Whiston and Sutton; it consists of Pebble Beds resting on Lower Mottled Sandstone, the latter cropping north of Eccleston Hill, and on the western margin adjoining the Halsnead fault, thence continuing south by Stocks Lane to Hough Green.

At Widnes is Messrs. N. Mathieson and Co.'s No. 1 well at east end of the works, 10 feet above Ordnance Datum, 4 feet 6 inches diameter and 30 feet deep; borehole 366 feet from surface, 6 inches diameter. Normal water-level 6 feet from surface. Pumping level (after 5 hours) 25 feet from surface. Yield 2000 gallons per day of 12 hours.

West of Runcorn Gap, *Ditton Brook* falls into the river. Its left bank drains Ditton and Tarbuck, where it crosses the Huyton fault, and enters the Upper Mottled Sandstone, and becomes *Tarbuck Brook*, dividing at Netherlee Bridge; the eastern rising in and traversing the Coal Measures near Huyton for a short distance, the western, *Childwall Brook*, rising near Roby. The right bank drains Childwall, Gateacre, and Acrefield, and the eastern slope of Much Woolton and Little Woolton. A well at Roby Hall has a top water of 80 feet above Ordnance Datum, that of Oakfield Quarry is 93, and is dry when Dudlow Lane well, $2\frac{1}{2}$ miles distant, is at work,

with the Croxteth fault intervening. The top water-level at the Belle Vale boring is 52 feet, that of Grange Lane 72, and that of Netherlee 37 feet.

The drift-covered promontory of Hale is drained by *Rams Brook*, rising at "Old Hut" and flowing south-east, falling into the *MERSEY* opposite Western Point.

West of Hale Head, by Hale Heath, Dungeon Point, Oglet Point, and Red Brow, banks of Boulder Clay form the coastline, and they are only broken by small streamlets. The *MERSEY* watershed is drawn by the Ordnance Survey as terminating at Red Brow and running by Speke, Much Woolton ridge, Waverton Knotty Ash, Huyton, to Knowsley Park, to which point it has already been traced.

WIDNES.—*Acres*, 3300; population, 24,919; rateable value, 90,303*l.* 17*s.*; supply of 1,440,000 gallons pumped daily into service reservoir from wells in the New Red Sandstone at Stockswell, where the water formerly rose to the surface 62 feet above Ordnance Datum, at Netherlee Bridge, where the water stands at 37 feet above O.D., and at other places in the Childwall valley; Widnes Improvement Act, 1867, and Widnes Local Board Act, 1875.

Liverpool Corporation Waterworks supply:—GARSTON, *acres*, 7568; population, 10,131; rateable value, 54,963*l.* Childwall, *acres*, 996; population, 207; rateable value, 1980*l.* Huyton with Roby, *acres*, 2917; population, 4060; rateable value, 37,342*l.* 2*s.* 1*d.* Little Woolton, *acres*, 1159; population, 1128; rateable value, 14,052*l.* Prescott, *acres*, 268; population, 6418; rateable value, 11,947*l.*