CHAPTER XXXII.

THE RIBBLE AND WYRE BASINS.

CATCHMENT BASIN XLV.

AREA, 7 square miles, drained by a brook rising on the peat moss at White Stakes, west of Farrington, and flowing through the depression in the Boulder Clay between Longton and Hutton into the *RIBBLE* estuary, of which basin it practically forms a part.

RIVER RIBBLE (XLII.).

Length, 54 miles; area, given by the Ordnance Survey Catchment Basin Map, 585 square miles, which has to be reduced by the 16 square miles belonging to the *DOUGLAS*, bringing the area to 569 square miles, of which 484 square miles consist of Carboniferous rocks, 2 of Permian, and 83 of Trias. Its southern watershed traverses Hutton, Farrington, and Bamber Bridge, where it attains an elevation of 150 feet; thence it ascends to Walton summit-level, 340 feet, and runs along the strike of the Rough Rock, rising to 425 feet on Duxon Hill, crosses the Fenniscowles synclinal of Lower Coal Measures, ascends to 675 feet at the Rough Rock of Withnell, and descends to 555 feet at the Withnell Col Valley; thence it ascends and traverses Anglezark Moors to 1215 at Bromley Pastures, where it trends east, and descends to Longworth and Roddlesworth Col Valley, which it crosses at 968 feet. Ascending the opposite hill across the strike of the Millstone Grit, it crosses the Gannister Coal synclinal at the top of Darwen Moor, 1319 feet above the sea; thence it trends eastwards, over hill-tops, most of which are capped by peat, forming Cranbury, Anshaw, Orrell, Hoddesden, and

Egerton Mosses; the latter is in the col valley at the head of *Broadwood* Brook, flowing into the Belmont reservoir. Leaving the moss, the watershed ascends Pike Low, and traverses the Lower Coal Measure synclinal, ranging through Haslingden, Oswaldtwistle, and Haslingden Moors above Haslingden. Crossing the col valley between the latter and Baxenden, it reaches Cribden Moor, where it turns at right angles, and trends north to Hambledon Hill. Here, east and west trough faults let in a belt of the Arley Mine of the Middle Coal Measures; the faults themselves are lead-bearing.

To the east of this watershed are the head waters of the *Irwell*, to the west and north those of feeders of the *Calder*. From Hambledon the *RIBBLE* and *Irwell* watershed trends east by the ridge of Hapton Park, which direction is continued until it terminates against the Central Pennine watershed, the northerly range of which has been described in treating of the head waters of the west central Yorkshire rivers. The *RIBBLE* Basin portion of the Pennine watershed, measured in a direct line from Todmorden, is 38 miles, while at Preston the north and south watersheds are only 5 miles apart. Northwards from the former place, the watershed passes east of Colne, by Barnoldswick, Long Preston, Horton-in-Ribblesdale, to a point between Hawes and Whernside, near sources of the *LUNE* and the *AIRE*.

The watershed of the right bank of the Upper *RIBBLE* runs parallel to the stream, and the left bank watershed as far as Giggleswick, the valley of Ribblesdale being only 3 miles in width. From Giggleswick the watershed trends west, the basin widening out, being drained by the tributary, the *Hodder*, the western limit of which is the county boundary between Yorkshire and Lancashire, running along the crest of the Bleasdale Fells. At Parlick Pike the watershed leaves the county boundary and crosses the col between the *Hodder* and *WYRE* basins, ascends the southern end of Longridge Fells, and then turning at right angles descends to the Drift plain, which it traverses to the sea between Blackpool and Southshore.

Following the left bank of the *RIBBLE*, up stream, from the estuary at Hutton, it flows through a valley entirely cut in Glacial Drift, consisting of the Upper Boulder Clay, Middle Sand, and Lower Boulder Clay, reaching a thickness of nearly 200 feet, and resting on a surface of the Pebble Beds of the New Red Sandstone, a little below high-water mark at Preston, sloping seawards, and rising to 50 feet above the mean sea-level at Samlesbury. The valley has an average width of three-quarters of a mile, an alluvial plain occupying the bottom, and occasionally older alluvial terraces the sides. Near the bottom of the alluvium of the lowest plain is a deposit of peat with fragments of roots and branches of trees, which may be traced to be a continuation of the thick deposits of peat fringing the western coast, which therefore grew after the valley of the *RIBBLE* had been excavated as deep as at present.

River Darwen.

The southern watershed is only 2 miles distant from the river between Penwortham and Walton-le-Dale. The tract of Drift country to the south is drained by small streams, which have not cut the valleys down to the rock. Opposite Frenchwood Park the *RIBBLE* changes its direction, and trends north-east, and receives the *Darwen*, draining a large area of Millstone Grits and Coal Measures, and about 3 square miles of Pebble Beds, and about a square mile of Permian Sandstone at Roach Bridge, where the Permian rests on various denuded Carboniferous rocks, and is cut off to the west by the fault bringing in the New Red Sandstone.

Following the left bank of the *Darwen*, up stream, it trends from the south-south-east, flowing over various Millstone Grits, and cuts a gorge through the Rough Rock at Hoghton Towers, which reach a height of 575 feet, and flows over Lower Coal Measures to Fenniscowles, where it turns at right angles and flows in the direction of the strike, the former direction being that of its tributary the *Roddlesworth*, which it receives at an elevation of 250 feet. The

feeders of this stream rise at the Belmont Col at 968 feet, and at Calf Heybrook at 1170 feet. From their source to the Roddlesworth reservoir of the *Liverpool Waterworks*, all the water is intercepted, except in excessive floods. The flood water, and the drainage of the lower part of the valley around Tockholes, is intercepted by the reservoir of the Star Paper Mills. Their supply is supplemented by a boring, which I recommended to be sunk, close to the works, to the Rough Rock, from which the water, absorbed at higher levels to the south, rises to the surface. The water, supported by the Shales beneath the Rough Rock, is intercepted by the boring in its path to the Fenniscowles synclinal.

From Fenniscowles to Witton the *Darwen* flows along the strike of the Lower Coal Measures, turning at right angles at Witton, and flows parallel to the Over Darwen fault west of the stream, to its source at Cranbury Moss. The fault throws up the Millstone Grit to the west, which is traversed by numerous tributary feeders. The banks of the *Darwen* drain entirely a Lower Coal Measure area, flowing past Over Darwen, and Lower Darwen, and Nova Scotia.

Over Darwen.—Population, 29,747; constant supply from reservoir; rateable value, 73,156*l.* 11*s.*; Darwen Waterworks Acts, 1847 and 1869. Rainfall observed at St. James's Vicarage, 564 feet above the sea:—

1876.	1877.	1878.	1879.	1880.
50·33	68·41	47·15	45·93	46·65

The average fall of the last 8 years is 51·17 inches.

Witton or Blackburn Brook.

The *Darwen* receives a tributary on its right bank, which flows in the direction of the strike of the Fenniscowles synclinal, afterwards traversed by the *Darwen*. The town of Blackburn extends on its left bank for a distance of nearly 2 miles. A tributary stream comes into *Witton* Brook at Little Harwood from the south, draining the Lower Coal

Measures at Belthorn, and another from the north draining the Millstone Grits.

BLACKBURN.—*Acres*, 4071; population, 104,012, with Borough Extension about 93,371; rateable value, 259,805*l.* 10*s.*, borough only, exclusive of outer district of supply; supply under Blackburn Waterworks Acts, 1845, 1849, 1861, and 1875; Blackburn Borough Gas, Water, and Extension Act, 1875; constant supply of about 2,000,000 gallons from streams and surface drainage.

RAINFALL taken by MR. BRYAN, C.E., in BLACKBURN WATERWORKS DISTRICT.

	Waterworks Office, above sea-level, 400 feet.	Preston New Road, 515 feet.	Witton, 315 feet.	Guide, 650 feet.	Pickup Bank, 720 feet.
1875	..	..	..	39·70	39·30
1876	45·47	..	..	42·50	47·60
1877	58·22	..	59·23	59·80	70·50
1878	36·31	45.88	41·05	42·40	44·50
1879	32·66	39·80	35·26	35·62	..
1880	38·73	45·34	41·57	40·29	44·97

Rainfall in 1880, at Dunsop Houses, 450 feet above the sea, 58·18; at Whitendale, 830 feet, 65·30 inches; at Cabin Hill, 1559 feet, 63·50 inches; at Middleknoll, 1298 feet, 49·70 inches; at Baxton Fell, 1540 feet, 49·60 inches.

The last Act obtained gives power to abstract water from the upper feeders of the *Hodder*, east of those taken by Preston, viz. *Brennand* and *Whitendale* Brooks.

The watershed between the *Darwen* and the *RIBBLE* runs along the strike of the Kinderscout Grit at Mellor, and crosses the fault bringing in the Pebble Beds at Rowley Fold, ranges along the high-road to Walton-le-Dale, where the Glacial Drift area, intervening between the two rivers, narrows to a sharp ridge resting on rock, at the top of which is Walton Church.

WALTON-LE-DALE.—*Acres*, 1683; population, 9286; rateable value, 37,682*l.*; artesian well in Millstone Grit, now

sinking at the Walton summit-level, to supply 150,000 gallons of water. The site was chosen by myself as likely to afford water free from organic impurity, and to give sufficient pressure in case of fires, at the mill property.

The left bank of the *RIBBLE* flows over a surface of Pebble Beds to a north-west fault bringing the Millstone Grits to the surface, which continue for a short distance, and the underlying Yoredale Beds rise to the surface, consisting of Upper Grit, black fossiliferous "Bolland Shales"; Lower Grit, which in Pendle overlie Yoredale Limestone; Shales, with Limestone, and the Carboniferous Limestone. Various feeders drain the Drift-covered country to the south, but the principal stream has a U-shaped course, rising at well-springs or the Kinderscout Grit at Bellington Moor End, then it trends south-west over the overlying Shales, which it recrosses near Ribchester Station, flowing west-north-west, at *Showley* Brook, over the Yoredale anticlinal, to Haywood Fold, where it turns to the north-east, and flows to the *RIBBLE*, as *Park* Brook, falling in west of the infall of the River *Calder*. The valley here is above half a mile across.

River Calder.

Length, 18 miles; area, 130¾ square miles; population of the basin in 1801, 36,826, in 1861 it had reached 118,725.

The course of the stream from its infall is at right angles to the strike of the various Yoredale and Millstone Grits through which the river has cut a gorge, at the bottom of which are glacial striæ, in the direction of the present stream.

A stream, the *Hyndburn*, comes in on the left bank, one of whose feeders rises at Warcock Green and flows past Oswaldtwistle, uniting with another feeder rising at Haslingden Moor, above sources of tributaries of the *Irwell*, at Church, and falls into the stream that has drained the Accrington district. Between Church and Clayton-le-Moors the Accrington stream is formed by a western feeder rising at Baxenden and an eastern flowing through Warmden Clough, and

then through the town of Accrington; all these streams drain a Lower Coal Measure area, but little obscured with Drift.

The watershed separating the *Calder* Basin from the *RIBBLE* runs along the escarpment of Rough Rock and Third Grit to Windy Bank, where it forms the watershed separating the waters of the *Darwen* from those of the *Calder* which terminates against it. The latter watershed trends south to Shin Bone Hill, Haslingden Moor, passing west of the Rishton reservoir impounding a stream flowing into the *Calder* below Clayton-le-Moors. The Leeds and Liverpool Canal passes into the *RIBBLE* Basin between Hoghton and Withnell at 360 feet above the mean sea-level, thence it crosses the *Roddlesworth*, the *Darwen*, and the *Calder* watershed, near Rishton reservoir; at Rishton it is 420 feet above the sea, and contours the Church Valley, and then passes into the Burnley Coalfield basin.

Oswaldtwistle.—*Acres*, 4883; population, 12,206; rateable value, 35,268*l.*; constant supply from drainage area of 288 acres of 380,000 to 442,000 gallons, stored in two reservoirs of 12 acres; Local Government Act, 1858; Provisional Order, 2nd April, 1864.

Accrington.—*Acres*, 3425; population, 31,435; rateable value, 93,672*l.* 10*s.*; constant supply from catchwater reservoir at *Dean* Brook, above the town; filtered; Accrington Gas and Waterworks Company's Acts, 1854, 1863 and 1869.

Accrington Waterworks Company supplies the following Local Authorities:—Clayton-le-Moors, *acres*, 937; population, 6694; rateable value, 16,155*l.* 5*s.* Great Harwood, *acres*, 2616; population, 6281; rateable value, 15,473*l.*

Following the River *Calder* up stream, east of the infall of the *Hyndburn*, it enters the Middle Coal Measures, and trends east-north-east to the infall of the River *Lamshaw*, where it returns to the north-west and south-east trend, which continues past Burnley and Holme to its source in the col at Thieveley, west of Todmorden. The source at Calder Head is 1¼ mile

to the north-east of Ere Well, the source of the *Irwell*, and close to the source of the Yorkshire *Calder*.

Following the right bank of the *Calder* from its source, it flows past Cliviger to Burnley, where it receives the River *Brun*, rising on the Pennine watershed between Hazel and Sheddon Edges to the west, and Black Hambledon to the east, the latter overlooking the watershed of the *Halifax Waterworks*. The Pennine or anticlinal fault in the upper part of the Saddleworth Valley becomes split up into several branches, ranging north-north-west through Denshaw; crossing the area drained by the head waters of the *Tame* into the basin of the *Roach*, the faults die out, except one ranging on the west side of Blackstone Edge. It is here a downthrow west, as it is further south, but is rather a synclinal than an anticlinal fault. At Todmorden the fault throws Yoredale Grit against Third Grit Shales. Still further north, the fault passes into the *Calder* Basin, and throws Kinderscout Grit against the shales of the Third Grit, the beds on both sides dipping west. The underground drainage of the Yorkshire side of the watershed is, however, not carried into the *RIBBLE* Basin, for the Black Hambledon watershed traverses an anticlinal parallel to the fault, and the beds then dip east, down the stream of the Yorkshire rivers. East of Rams Clough and Hazel Edge, the fault changes the direction maintained from Central Cheshire, and trends eastward of north, and dies out in the Millstone Grits of the Forest of Trawden; the east-north-east strike of the Yoredale Beds being unbroken, where the line of dislocation would have occurred, between the basins of the *RIBBLE* and the *AIRE*.

On the right bank of the River *Brun*, it receives a stream draining Worsthorne, and the Millstone country of Hazel Edge. North of Rowley Bridge, it receives the River *Don*, rising at Robin Hood Well, on Boulsworth Hill, on Yoredale Shale, near the *Halifax Waterworks'* watershed. Thence it flows down the dip of the strata, crossing the Millstone Grit and Lower Coal Measures, and entering the Middle Coal

Measures south of Haygate, receiving on the left bank *Swinden* water draining Entwistle Moor and Ham.

RAINFALL observed by Mr. BRYAN, C.E., in BURNLEY DISTRICT.

	Burnley, 450 feet.	Rose Grove, 493 feet.	Brierfield, 402 feet.
1875	..	39·55	38·72
1876	38·86	42·00	38·95
1877	49·32	57·48	55·78
1878	36·86	40·41	40·10
1879	33·41	38·29	37·37
1880	38·21	42·41	52·26

BURNLEY.—*Acres*, 1018; population, 58,882; rateable value, 115,540*l.*; supply from gathering and surface springs in Entwistle and Worsthorne townships, stored in three reservoirs, yielding 1,229,349 gallons of unfiltered water; under 9 & 10 Vict. c. 119; 17 & 18 Vict. c. 67 (both repealed); and "The Burnley Borough Improvement Act, 1871."

BURNLEY WATERWORKS DISTRICT, RAINFALL observed by Mr. J. EMMETT.

	Waterworks, 420 feet above the Sea.	Swinden Reservoir, 750 feet above O.D.
1878	34·58	43·00
1879	..	31·11
1880	..	36·37

A large area is drained by the River *Henburn* and its tributaries, falling into the *Calder* at Royle. Its left bank drains the district of Marsden, Hebson, Catlow, Southfield, and under the name of the River *Lamshaw*, its feeders traverse the Millstone Grit of the Forest of Trawden, including Trawden, Winewall, and Wycoller.

COLNE and MARSDEN.—*Acres*, 5331; population, 11,970; rateable value, 30,527*l.*; intermittent and insufficient supply

from reservoirs of *Colne Water Company;* Colne Water Act.

NELSON.—*Acres*, 822; population, 10,381; rateable value, 18,300*l.*; constant supply of 160,000 gallons from three brooks flowing into *Walverden* water, which stream is impounded by the Local Authority, under their Acts of 1866 and 1878, in a service reservoir holding 2,000,000 gallons, and a storage compensation reservoir for millowners on the stream, holding 25,000,000 gallons.

A tributary stream falls in on the right bank between Colne and Lawerford, draining the col valley connecting the basin of the Lancashire *Calder* with the Yorkshire *AIRE*, at the head of which are the reservoirs of the Leeds and Liverpool Canal, situated on the shales separating the Kinderscout and Upper Yoredale Grit, and on the Sabden Shales overlying the Kinderscout Grit.

Another feeder rising on the Upper Yoredale Grit, on Burn Moor, at the eastern end of the Pendle Hill, flows over the Millstone Grit of the Forest of Pendle, and falls into the right bank of the *Lawerford.* Following the latter stream on its right bank, it enters the Middle Coal Measures of the Burnley Coalfield, at Old Laund Hall, near Whateley Lane, and flows over them to the infall of the stream into the *Calder*, north-west of Burnley; they continue on the right bank of the *Calder*, by Padiham, the river following their strike, until a fault, ranging through Simonstone Hall, cuts off their western extension. A little further west the *Calder* changes its direction, and cuts a gorge, first through a ridge of Millstone Grit, ranging east-north-east, and then through the higher and parallel ridge of older Yoredale rocks; between the two ridges is the valley drained by *Sabden* Brook, running over the shales, named after the village. The Sabden Shales occupy a horizontal space on the dip, of nearly three-quarters of a mile, resting on the Kinderscout Grit, which is only separated from the Upper Yoredale Grit by a thin band of shale. The Lower Yoredale Grit and underlying Pendleside Limestone are absent here,

and the Lower Yoredale Shale occupies a large tract, extending to and beyond the *RIBBLE*, which the *Calder* joins at 102 feet above the mean sea-level near Mitton Wood.

PADIHAM and HAPTON.—*Acres*, 937; population in 1881, 8983; rateable value, 18,151*l.* 10*s.*; constant supply from reservoir storing surface water; Padiham Water Act, 1874.

Following the left bank of the *RIBBLE* towards its source, a tract of Permian Sandstone and Marl, about 1½ square mile in extent, rests on the Lower Yoredale Shales, at Low Moor, near Clitheroe, where an anticlinal throws up the Carboniferous Limestone ranging north-east by Chatburn and Downham.

CLITHEROE.—*Acres*, 2017; population, 10,177; rateable value, 30,263*l.*; constant supply of 256,700 to 266,000 gallons from service reservoir, holding 500,000 gallons, impounding streams flowing off Fells in the townships of Grindleton and West Bradford, five miles west of Clitheroe.

At the close of the Carboniferous period the British Isles, in common with the neighbouring parts of Europe, were subjected to great lateral pressure, acting in a general north and south direction, which produced considerable terrestrial movements in the earth's crust, causing the strata to be thrown into a series of flexures, ranging in a direction at right angles to that of the pressure exerted. In France, Belgium, the South of England, and in Yorkshire, the direction of the axes of these flexures is nearly east and west; in Lancashire, in the hills of the Pendle range, east-north-east (E. 35 N.). The most important of these rolls or anticlinal axes now traverses the Yoredale Rocks and Millstone Grit separating the Lancashire and Yorkshire Coalfields from that of Durham. These anticlinal arches, more or less traversed by fissures, were readily attacked by denudation, and it is due to this cause that anticlinals are found along the lines of the valleys, while synclinals occur in hills forming lines of strength. It was by this denudation, at the

close of the Carboniferous Epoch, that so large an area of Coal Measures were swept away.

The sections that have been drawn by the Geological Survey across the South Lancashire and Burnley Coalfields, and the surrounding tracts of older carboniferous rocks, well exhibit the series of flexures or foldings that the rocks of the Pendle range have thrown by lateral pressure. These flexures traverse the country in a series of wave-like curves, the axes of which travel in an east-north-east and west-south-west direction, and form the Sykes, Slaidburn, Clitheroe, and Rossendale Anticlinals of Messrs. Hull and Tiddeman.

The lines of the geographical valleys range through the anticlinals, as the valley of Sykes, Slaidburn, and Clitheroe, while the synclinals traverse the fells and hills intervening. The curve of the Rossendale Anticlinal, ranging through the ancient forest of that name and through Anglezark Moor, is low and gentle, and north and south of it lie respectively the Wigan and Burnley portions of the Lancashire Coalfield, which lie in basins, true synclinals of deposition in the past, and forming geographical valleys at the present time. An examination of the thicknesses of the strata lying between the well-marked and well-known coal-seams of the Middle Coal Measures enables the relative rate of movement, as well as its position and duration, to be ascertained, which was the first expression of the continued subsidence that brought about those flexures which separated the Lancashire Coalfield into distinct tracts.

The Carboniferous rocks of this area consist of the following sequence, in ascending order:—

Mountain Limestone.—The base is seen resting on Silurian rocks in the valley of the *RIBBLE*, north of Settle, near Malham Tarn. At Clitheroe the bottom beds are not brought to the surface by the anticlinal, and the thickness without these is no less than 3250 feet. The limestones of the Forest of Pendle are of great value for their lime-producing

qualities, both the lower black bituminous varieties and the upper grey beds, the former being the most desired when whiteness is an object, the whole of the colour being expelled by burning.*

Shales with Limestone.—These series consist of an alternation of shales, thin limestone, cement stone, and thin ironstones, giving rise to springs containing sulphuretted hydrogen gas; one of these occurs at Clitheroe, and has a bath-house attached. The thickness of this series is not less than 3225 feet.

Lower Yoredale Grit.—This bed resembles the Gannister beds of the Coal Measures in appearance and hardness; it is often absent; but, when present, it invariably forms the base of the Bowland shales, so named by Professor Phillips, and plays an important part in the scenery of the Forest of Pendle, the steep slopes of which are all composed of the disintegrating shales of this age, reaching a maximum thickness of 700 feet. The most common fossil is *Posidomya Gibsoni;* Goniatites and fish remains occur, as well as seams of ironstone, which give the shales an appearance of Coal Measures, which has led to many fruitless borings.

Upper Yoredale Grit is well seen in the quarries at Longridge Fell, near Preston, which are very extensive, the grit reaching a thickness of not less than 1000 to 1200 feet. Overlying the Upper Yoredale Grit, which contains impressions of plants, occurs a bed of shale 200 feet in thickness, on which rests the Kinderscout Grit, forming the base of the Millstone Grit Series, which is divided into four great divisions by three thick beds of shale, and these beds are often again subdivided by intercalated shales, often of considerable thickness. These sub-divisions, though useful for purposes of identification in Derbyshire, Lancashire, and South-Western Yorkshire, are local, and mere divisions of

* 'Memoirs of the Geological Survey.' Mr. R. H. Tiddeman, in the 'Geology of the Burnley District.'

convenience, the whole of the Millstone Grit, physically and biologically, forming one formation.

Various small streams drain the back of Pendle Hill, which rises to 1831 feet, and fall into the left bank of the *RIBBLE*, chiefly rising on the Bowland Shales, intervening between the Yoredale Grits. The most important is *Ings Beck*, which constitutes the county boundary, both banks of the *RIBBLE* being in Yorkshire above the infall of this stream near Sawley. The north-east trend of the *RIBBLE* valley, commencing at Preston, is continued to Gisburn, when it turns first northward, and then north-north-west, running close to the Pennine watershed by Long Preston, Settle, and Horton-in-Ribblesdale, to its source east of Wharnside.

Following the *right* bank of the *RIBBLE* from its source through Ribblesdale, no place of importance is passed until Giggleswick is reached, at the entrance of the valley. At Bolton-by-Bowland a feeder comes in from the north, draining Yoredale rocks, and several smaller streams between its infall and that of the important tributary the *Hodder*. These streams drain the high moors above Grindleton, Waddington, and Great Milton, where the infall of the *Hodder* occurs at 120 feet above the sea. The Yorkshire county boundary follows the *RIBBLE* from the infall of *Ings Beck* to that of the *Hodder*.

River Hodder.

The *Hodder* is 18 miles in length, its valley being coincident in direction with that of the *Calder*. It drains 103½ square miles of Yoredale rocks, which were inhabited in 1861 by 3388 persons. The left bank of the *Hodder* is situated wholly in Yorkshire, the county boundary following the river to a point a little above Whitewell, where it crosses the stream, and, passing over the right bank of the basin, ascends the Bleasdale Fells, and follows the watershed. No streams of importance drain the left bank.

Feeders on the right bank of the *Hodder*, below Newton, in Whitendale and Brennand valleys, are to be impounded for the additional supply of Blackburn, by powers granted by an Act passed in 1880. The *River Langden* and its tributary, *Hareden Brook*, draining the wild valleys on the west side of the Sykes col valley, are impounded by the *Preston Corporation Waterworks*, the conduit being laid on the west side of the *Hodder*, through Chipping and Longridge.

River Loud (tributary of the *Hodder*).

The watershed separating the basins of the *WYRE* and *RIBBLE* ranges south from Fair Snape, 1701 feet above the sea, through Parlick Pike, 1476 feet, then south-west to Beaton Fell, 674, whence it trends south-south-east to Longridge Fell, descending to less than 400 feet in the very fine col valley separating the Bleasdale and Longridge Fells. Looking down the valley of the *Loud*, from its source between Beaton and Parlick Fells, the watershed is hardly noticed, and the natural course of the stream appears to be to the south into the basin of the *WYRE*, but at Loudscales the stream turns and, describing a U-shaped course, flows to the north-east, following the strike of the Yoredale Rocks, and falls into the *Hodder* near Chipping.

The right bank of the *RIBBLE*, from the infall of the *Hodder*, flows at the foot of Longridge Fell, which is composed of the Upper and Lower Yoredale Grits, separated by Shale, and dipping under the Millstone Grit, traversed by the river. At the north end of the Fell is Stoneyhurst College and the ancient village of Ribchester, at the south end is the village of Longridge, near which are the quarries above referred to, in the Upper Yoredale Grit, largely used at Preston as a building stone. Westward, the Glacial Drift gradually increases in thickness, and extends to the sea, and southwards over the whole of the district called the "Fylde," in the basin of the *WYRE*. Rainfall observed

at Stoneyhurst College by the Rev. S. J. Perry, at 376 feet above the sea:—

1876.	1877.	1878.	1879.	1880.
47·51	60·30	45·36	42·39	50·27

At Red Scars, near Grimsargh, the triplex arrangement of the Glacial Drift is well seen, true Boulder Clays being separated by a Middle Sand. Westward, they are more or less obscured by landslips, terraces of old alluvium, and grass. Good sections of laminated Clays and Middle Sands have recently been exposed in the construction of the new railway station at Preston. The Upper Boulder Clay forms the surface of the country westward by Lee, Ashton, Lund, and Freckleton, where there is a good cliff section at the Point. Here and there the Middle Sands come to the surface through the Upper Boulder Clay, as at Kirkham. In the district west of this place, at Moss Side, the surface of the Glacial Drift sinks beneath high-water mark, and the country is covered with peat moss, extending up to Southshore, near Blackpool, bounded to the north by a bluff of Boulder Clay, and southward by the sea, fringed with a range of Sand Dunes, commencing at Lytham, and extending through St. Anne's to Southshore. The district lying between Preston, Lytham, and Southshore is about 40 square miles in extent; it drains entirely into the tidal estuary of the *RIBBLE*, and can hardly be considered within the basin of that river.

PRESTON.—*Acres*, 2820; population, 96,532; rateable value, 265,000*l.*; constant supply of 2,700,000 to 5,000,000 gallons from gravitation waterworks; springs and gathering-ground near Longridge, 6 miles from Preston, stored in Alston reservoir, holding 73,000,000 gallons; Spade Mill, 110,000,000 gallons; Grimsargh, 59,000,000 gallons; Dilworth, 24,000,000 gallons; supplemented by water occasionally pumped from the River *Loud* and *Cowley* Brook; impounding works in *Langden* and *Hareden* Brooks, at Sykes, tributaries of the *Hodder*, 14 miles from Longridge; the

water is passed through wire sieves; works under Preston Waterworks Act, 1863; and Preston Improvement Act, 1869.

Rainfall at the *Preston Waterworks* Office, 100 feet above the sea, for the past thirty-two years:—

Year.	Inches.	Year.	Inches.
1849	34·03	1865	30·84
1850	35·07	1866	50·05
1851	32·92	1867	34·83
1852	43·94	1868	37·78
1853	30·98	1869	44·61
1854	34·86	1870	39·51
1855	27·70	1871	34·11
1856	33·09	1872	53·10
1857	32·89	1873	38·18
1858	30·51	1874	43·23
1859	36·05	1875	34·11
1860	37·86	1876	37·15
1861	35·90	1877	52·40
1862	41·76	1878	35·71
1863	42·10	1879	32·71
1864	32·30	1880	36·36

The average rainfall at Preston, from 1851 to 1865, was 34·84 inches, and from 1866–80 was 37·84, showing an increase of average annual rainfall of 3 inches.

In 1880, Mr. Hudson Reah, C.E., states, the rainfall at Jeffrey Hill was 47·52 inches; at Knowl Green, 42·14; at Spade Mill, 40·03; at the River *Loud*, 42·97; at Alston, 41·14; at Langden, 66·52; at Hareden, 67·34.

Fulwood.—Population, 3725; rateable value, 15,104*l.*; constant supply at present from Grimsargh reservoir of the Preston Corporation, who have no Parliamentary powers to supply. A boring in the New Red Sandstone is now being carried out, and has reached a depth of 250 feet, for an independent supply at a site chosen by me. The water obtained is free from all organic impurity.

Kirkham.—*Acres*, 857; population, 3840; rateable value, 9069*l.*; constant supply from *Fylde Waterworks Company's* reservoir at Scorton, in the Grizedale Fells, in the basin of the *WYRE*, south-east of Lancaster; under 24 & 25 Vict. and 33 & 34 Vict. The Company also supply Garstang, Lytham, Blackpool, and Fleetwood, and are now seeking further powers.

Lytham.—*Acres*, 659; population, 4122; constant supply from *Fylde Waterworks Company;* rateable value, 16,690*l.* 14*s.* Rainfall:—

1878.	1879.	1880.
33·36	34·32	32·19

St. Anne's-on-Sea.—*Acres*, 220; population, 1179; rateable value, uncertain; district only just formed; supply constant, from *Fylde Waterworks Company.*

RIVER WYRE (*XLI.*).

Length 24 miles; area, 208 square miles, of which Yoredale Grits and Shales occupy 80 square miles, Permian Sandstones, 18; and Keuper Marls, 110. The sea frontage of this basin is considerable, extending from Southshore to Rossall Landmark, and from there to Pilling, a distance of 15 miles.

The coast drainage between Blackpool and Rossall Point passes directly to the sea, and constitutes a small separate drainage area of about 8 square miles, which tract consists of Upper Boulder Clay resting on the Middle Sands, which appear in the cliffs, and occasionally comes to the surface. The rainfall received in this area is quickly conveyed to the sea over the sloping surface of the clay, or pours down vertical joints in it to the sands beneath, which discharge a portion of it in a line of springs at the base of the cliffs, flowing through the shingle between tide-marks.

Blackpool.—*Acres*, 2358; population, 14,448; rateable value, 85,000*l.*; constant supply from the *Fylde Waterworks Company.* The Corporation would prefer sale by meter to them, so that they should undertake the distribution.

RAINFALL observed by Mr. GEO. SHARPLES, 29 feet above the Sea.

	First Half-year.	Second Half-year.
1870	11·12	20·29
1871	10·93	19·01
1872	19·35	28·00
1873	12·00	14·27
1874	8·76	20·97
1875	11·03	22·90
1876	10·72	22·05
1877	19·25	30·12
1878	13·50	18·42
1879	13·80	17·80
1880	11·50	23·22

The average rainfall for the last twenty-five years is 32·88 inches. Of the 34·72 inches of rainfall in 1880, 25·22 inches were evaporated.

FLEETWOOD.—*Acres*, 2900; population, with Thornton, 6513; supply from *Fylde Waterworks Company*.

Following the left bank of the *WYRE*, up stream, from Fleetwood, a tract of tidal alluvium forms the narrow strip of land between the sea and the estuary of the river; much of it is somewhat below spring-tide high-water mark, and both sea and river are artificially kept out; but the sea-walls are considerably destroyed, and in very bad condition. Wells at Cleveleys produce brackish water. The river widens out southwards, and presents a wide expanse of tidal waters, contracting at the point where they are crossed by Shard Bridge, above which the tide flows for a considerable distance. *Thistleton Brook* and other feeders falling into the left bank drain the flat country around Poulton-le-Fylde, Thistleton, Eccleston, Wharles, and Inskip, consisting of Upper Boulder Clay resting on sands. Nowhere is the rock seen; but Keuper Marls have been proved under the Glacial Drift in a boring at Poulton to a depth of 179 yards. Rainfall at Elswick Lodge, 50 feet above the sea:—

1876.	1877.	1878.	1879.	1880.
35·85	51·17	35 59	32·21	33·08

Stalmine registration sub-district contains 13,589 *acres*, with a population of 3281. Poulton-le-Fylde registration sub-district contains 20,863 *acres*, and a population of 25,346.

River Brock.

At St. Michael's-on-Wyre, the river receives the River *Brock*, 10 miles long, which a little east of the vicarage is joined by, on its left bank, *Woodplumpton* or *Blundel* Brook, rising near Longridge, at an elevation of 350 feet, and flows between Grimsargh and Goosnargh, through a Drift valley, resting on Yoredale rocks, past Broughton, Woodplumpton, and Woodsfold. At Carver's Bridge this brook is joined by *Barton* Brook, draining east of Barton Lodge, Yoredale rocks first appearing at 150 feet above Ordnance Datum on this stream near Mackareld House, and 175 feet on its tributary *Westfield* Brook. The watershed between these streams and the *Loud* rises to 425 feet.

Following the left bank of the *Brock*, up stream, from the infall of this brook, it passes under the Lancaster Canal at 70 feet, under the London and North-Western Railway at Brock Station, east of which it crosses the fault throwing up the Mudstones of the Yoredale series, appearing beneath the Drift at 100 feet above the mean sea-level.

The direction of the River *Brock* valley is continued by the *WYRE* from St. Michael's to Poulton-le-Fylde, through a valley cut in the Glacial Drift, forming steep cliffs of no great height at Shard Bridge. Before the deposition of the Cleveleys Estuarine deposits and the underlying peat, the river probably continued flowing in this direction, and reached the sea at Cleveleys, or at a point further seawards, as the coast has been and is rapidly wearing back by tidal erosion. East of St. Michael's the *WYRE* valley turns north-eastward, passing Churchtown, which is built on Boulder Clay resting on Permian Red Sandstone.

St. Michael's registration sub-district includes 16,439 *acres*, with a population in 1881 of 3184.

River Calder.

This river is 8 miles long; rising in the Yoredale rocks of Luddock's Fell, on the watershed of the *Hodder*, overlooking Fiendsdale, 1500 feet above the sea, it flows south and south-west through a deep gorge, emerging on to the plain near Garstang Railway Station, and falls into the *WYRE*, opposite Garstang Church, at about 30 feet above Ordnance Datum.

The tops of the Bleasdale and Grizedale Fells consist of sweeping undulations, in the bottoms of the hollows of which occur trough-shaped brook and river valleys, with steep sides; the *Calder* receives its first waters from brooks running over the surface of the upland, undulating, peat-covered plain to the north-east of Winny Hill. The levels of the sources of these streams are from 1485 to 1350 feet above the mean sea-level. These brooks, and the small tributary rills running into them, flow at the bottom of small trenches or slots of various depths, from 3 inches to 15 feet, excavated in the peat down to the underlying deposits of rain-wash, which they have seldom fall enough to denude. On the lower slopes of the Fells, however, and here and there on the summit-levels, where the slope is considerable, the rush of the rain under the peat has fairly lifted it up, carried it away, and left a vacant space of bare rain-wash, scattered here and there with loose stones, often many pounds in weight, borne from above. These bursts, or "brasts," as they are called in the Lancashire dialect, generally appear to have exerted that force with greatest intensity at one point, below which it radiated out in a fan- or cone-shaped area, the apex pointing upwards. The peat-cleared tracts have generally become the storm-channels of the water falling on the upper slopes, or rather that portion which is in excess of the soakage powers of the peat to hold back. These storm-waters, exuding between the peat and the rain-wash, rush with great violence over the Fell-sides, carrying stone and earth derived from the latter. Most of this is carried into the brooks below, but some is spread over the peat-cleared

areas, which thus become stony deltas of apparently invisible streams, draining a tract of country in which a loose stone is never seen.

It is clear that if one of these brooks running under the peat, over a flattish country, should flow over an undulation, the slope of which is less steep than that from the point where the stream enters the slope to the level of the base, it will form itself a trench or valley of a depth equal to the number of feet between the two points.

The *Calder* crosses the fault, throwing in the Permian Sandstone at Sandholme Mill, and falls into the *WYRE* above Garstang Church; its south-west trend is continued by the *WYRE*, as far as the infall of the *Brock*.

The valley of the *WYRE*, from the infall of the *Calder*, trends northward through a broad valley excavated in the Glacial Drift at Garstang, and then through a deep valley in the Yoredale rocks at Scorton.

Grizedale Brook.

This tributary falls into the *WYRE* between Garstang and Scorton: it rises at Grizedale Head, 1200 feet above the sea, north of the source of the *Calder*, and flows entirely over Yoredale rocks. It is impounded in the picturesque valley, called Nickey Nook, by the *Fylde Waterworks Company*. The Yoredale Grits are shattered and faulted, and it is found difficult to render the reservoir watertight. Another reservoir has been constructed on the hill to the south. The rainfall, at 519 feet above the sea, was:—

1876.	1877.	1878.	1879.	1880.
44·67	59·40	37·76	39·32	44·56

On the right bank of the *WYRE* a large area drains directly into Morecambe Bay, a low watershed traversing Cockerham Mosses, drained by the River *Cocker* and River *Pilling*. Under the peat moss is a raised beach, which is well seen at Preesall. The Preesall shingle thins out eastward, against a slope of Glacial Drift, west of Garstang.

The town is built on Glacial Drift resting on Permian Red Sandstone, in which is a well at Higher Crookey.

Rainfall at Vale House, Garstang, 455 feet above the sea :—

1876.	1877.	1878.	1879.	1880.
44·71	61·50	41·50	38·46	43·38

Average of the past 18 years, 44·83 inches; average rainy days, 199.

Garstang registration sub-district contains 31,087 acres, with a population of 5833.

The *Lancaster Corporation Waterworks* take the upper portions of the feeders of the *WYRE* for their town supply, and the remainder, including *Tarnbrook Wyre* and *Marshaw Wyre*, forms their compensation water area for millowners who have a private reservoir lower down the *WYRE*.

Mr. Jackson, C.E., proposed the upper *Brock* as a source of water-supply for Liverpool; he proposed to make a reservoir at Admarsh, with an embankment 110 feet in height, which he calculated to yield a daily supply of 30,000,000 gallons, derived from 4250 acres drained by the *Brock*, and 6000 in Wyredale, and some feeders of the *Loud*, not appropriated by the *Preston Corporation Waterworks*.

CHAPTER XXXIII.

THE NORTH LANCASHIRE BASINS.

RIVER LUNE (*XXXIV.*).

LENGTH, 42 miles; area, with tributaries, 418 square miles, of which about 104 square miles consist of Silurians, 144 of Carboniferous Limestone, 168 of later Carboniferous rocks, chiefly Yoredales, and 2 of Permian Sandstone.

The watershed trends east from the mouth of the river, over the crest of the Grizedale Fells, forming the northern margin of the *WYRE* and part of the *RIBBLE* Basin. West of Settle the watershed turns abruptly north, running parallel to the *RIBBLE*, over the ridge of Whernside, 2414 feet high, to a point west of Hawes, where it falls into the central Pennine watershed, separating the eastern from the western rivers. This it follows for a distance of only 2 miles, overhanging the head waters of the *URE*, after which it trends a little north of west, and separates the upper basin of the *LUNE* from the head waters of the *EDEN*, that river, the *LUNE*, and the *RIBBLE* rising within a few miles of each other. The northern boundary of the *LUNE* Basin is formed by the great east and west watershed traversing the north of England in nearly a straight line, with the exception of the southern deflection produced by the occurrence of the remarkable valley of Mallerstang, in which rise the *EDEN* and the *URE* within a quarter of a mile of each other. The watershed from Mallerstang, skirting the *EDEN* valley, crosses Ravenstonedale Common to Ashby Winderworth Common, and trends west over Shap Fells; the watershed generally coinciding with the division between townships, it is crossed by the London and North-Western Railway at Hardendale Fell, south of Shap Station,