

area. The rainfall in the hilly portion of the catchment amounts to 33 inches per annum, whilst in portions of the plain country towards the Murray it does not exceed 18 inches, the average for the whole catchment area being about 24 inches. The length of the Campaspe is about 120 miles, and it joins the Murray at Echuca.

Plate 26.



WEIR, CAMPASPE RIVER AT ROCHESTER, VICTORIA.

The Loddon takes its rise in the Great Dividing Range, near the town of Daylesford, and joins the Murray at Pental Island, near Swan Hill, its total length being about 200 miles. The drainage area is about 5,600 square miles, of which 1,800 square miles might be regarded as contributing, and the balance, 3,800, as non-contributing. The average rainfall throughout the basin is 19

Plate 27.



PYRAMID HILL, LODDON VALLEY, VICTORIA.

inches per annum. On the lower reaches of the river the banks are very low, and in times of excessive rainfall the flood-waters spill over the banks, and naturally irrigate large areas of Polygonum country. The country in the valley of the lower Loddon is very flat, there being only one small hill in it, known as Pyramid Hill, (Plate 27.)

The Mitta Mitta (Plate 28) is probably, after the Goulburn, the best Victorian tributary of the Murray. It rises in the Bowen Mountains, and flows through hilly country, reaching the Murray a few miles above Albury. The flow of the Mitta is well sustained throughout the year. The drainage

area is 2,400 square miles, the average rainfall over the whole of the catchment is 38 inches per annum, with a mean annual discharge of 54,400,000,000 cubic feet. The principal tributaries are the Bundarra h, Snowy and Talangatta Creeks.

Plate 28.



MITTA MITTA RIVER AT TALLANGATTA, VICTORIA.

Extensive dredging and sluicing operations are carried on along the banks of the creeks which flow into the Mitta Mitta. The immense quantities of sludge resulting from the operations are causing a serious pollution of the Mitta, and also the Murray, and I will refer to this question later on.

The catchment area of the Kiewa River (Plate 29) is only 700 square miles, but it has an exceedingly high rainfall and can be relied upon to make an effective and extremely regular contribution to the waters of the Murray.

The Ovens (Plate 30) rises in the Barry Mountains, near Mount Hotham, and joins the Murray about 20 miles below Corowa. Its length is about 110 miles, and it has a drainage area of about 3,000 square miles, with an average rainfall of

Plate 29.



KIEWA RIVER AT KIEWA, VICTORIA.

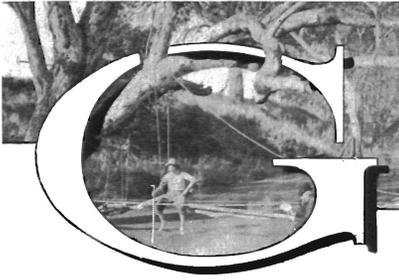
40 inches per annum. In heavy rainfall large quantities of water are discharged, the highest volume actually measured being 302,000 cubic

Plate 30.



OVEN'S RIVER AT WANGARATTA, VICTORIA.

feet per minute. The flats along the river are liable to frequent flooding, and are, therefore, not suitable for irrigation. The upper part of the river is particularly picturesque, and the town of Bright is one of the favourite tourist resorts of Victoria.



GAUGING OF THE MURRAY AND ITS TRIBUTARIES.

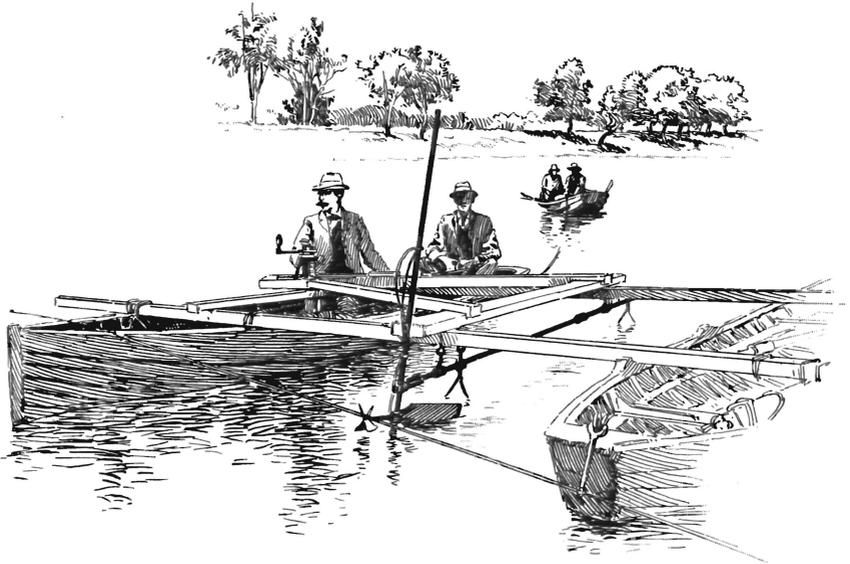
In a country like Australia, where the available supply of water is small compared with the demand, a knowledge of the quantity of water that may be relied on to be obtainable from any proposed source of supply is an essential preliminary to the discussion of any scheme for diversion and utilisation. The quantity of water needed for irrigation is very great, and the area of irrigable land will always be in excess of the capabilities of the volume of water available. Hence it is most important to ascertain with precision what the volume really is, so that works of diversion and distribution may not be constructed in excess of the water that can be supplied. There are many methods of gauging, but the most preferable is that of obtaining the velocity of the streams by the use of the electric current-meter.

The gaugings of the Murray at Albury extend from January, 1877, and the records show that the highest known discharge occurred in June, 1880, when the flow reached the respectable volume of 3,214,000 cubic feet per minute. The lowest discharge ever recorded was in February of this year, when the flow did not exceed 17,500 cubic feet per minute. The highest yearly volume passing Albury was in 1894, when 264,383,000,000 cubic feet passed the gauging-station. The precipitation for that year amounted to 46 inches over the catchment area, the run-off being 38 per cent. In 1902 the volume discharged at Albury for the year was the lowest on record, viz. : 41,091,000,000 cubic feet. The previous lowest record was in 1884, when the discharge reached 78,697,000,000 cubic feet, or nearly double that of the abnormally low year of 1902.

The Murray has been gauged at Mildura since 1865. During the flood of 1870 the enormous volume of 1,141,728,000,000 cubic feet was discharged. It is estimated that in the height of the flood the flow was 6,000,000 cubic feet per minute. By comparing the records at Echuca and Mildura for 1870, it will be seen that about 60 per cent. of the flood-waters passing Mildura were contributed by the Murrumbidgee. The severity of the late drought had a very marked effect at Mildura, and the river fell to 14,400 cubic feet per minute in April last. The total discharge for the year 1902 was only 57,517,000,000 cubic feet, or about 5 per cent. of the highest known discharge.

The gaugings of the Murray at Morgan (Plate 31) extend from 1884, and the records show that the highest discharge occurred in 1890, when the maximum volume of 4,000,000 cubic feet per minute passed the gauging-station. The total volume for that year amounted to 1,067,000,000,000 cubic feet. No doubt this volume was exceeded during the flood of 1870, but unfortunately there are no records sufficiently reliable to support this assumption. In 1902 the exceptionally meagre rainfall, and the absence of snow on the mountains, had the inevitable effect of decreasing the annual volume at Morgan when it reached its lowest point, viz. : 105,000,000,000 cubic feet, or only about 10 per cent. of the 1890 flow. In April of

Plate 31.



GAUGING THE MURRAY AT MORGAN.

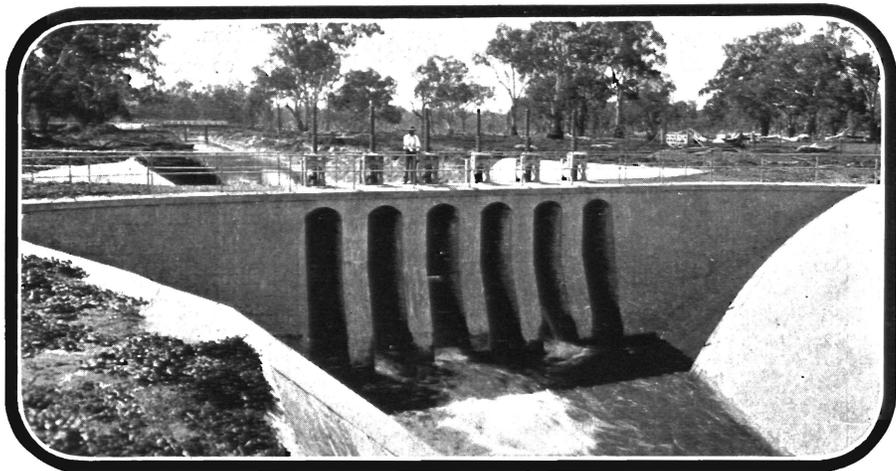
this year the mean discharge for the month decreased to 44,500 cubic feet per minute, which is the lowest recorded mean monthly discharge. It might be pointed out that in order to provide a navigable depth for the class of boats trading on the river, South Australians ask that a minimum volume of 337,000 cubic feet per minute be provided, and this was reached for only four months since the beginning of 1902.

With regard to the Murrumbidgee, the most reliable stream measurements have been made at Hay, where daily readings have been recorded since 1885. The highest annual volume of discharge was reached in 1894, when something like 400,000,000,000 cubic feet passed the gauging-station, representing a mean discharge throughout the year of 12,700

**The
Murrumbidgee
at Hay.**

cubic feet per second. In 1902, owing to the non-appearance of the usual spring rains and the mildness of the winter on the ranges forming the upper portion of the watershed, the discharge only amounted to 18,500,000,000 cubic feet for the whole year, or a mean flow of 600 cubic feet per second. Such a low volume as this is absolutely without parallel in the records, the nearest approach to it occurring in the year 1898, when the yearly volume reached 60,000,000,000 cubic feet, or three times the volume of 1902. The lowest mean daily discharge was recorded in February, 1903, being 200 cubic feet per second, showing how greatly the flow fluctuates and the futility of diversion schemes unaccompanied by storage provisions. There are no means of estimating the proportion of rainfall discharged by the Murrumbidgee, as the published records do not include the highest peaks of the Dividing Range, where the heaviest falls of rain and snow occur.

Plate 32.



GUNNINGBAR CUTTING AND REGULATOR.

An inspection of the tabulated results of stream measurements at Forbes and Cowra gauging-stations for the past ten years stamps the Lachlan River with a reputation for irregularity of flow which is, perhaps, not paralleled by any other stream in the Commonwealth. As illustrative of the rapid fluctuations which take place in the volume discharged by the river, the years 1900 and 1902 might be quoted. In July, 1900, a sudden downpour of rain, aided by melting snows in the ranges forming the upper portion of the Lachlan gathering ground, caused the river to rise from 19 feet to 46 ft. 8 in. in twenty-six hours, or at the rate of more than 12 inches per hour, at the Cowra gauge staff. According to the evidence of old residents, this height was only

**The Lachlan
at Forbes
and Cowra.**

exceeded during the great flood of 1870. The estimated discharge at this height, being the best deduction possible from the observations at lower stages, was found to approximate to 1,800,000 cubic feet per minute. This volume was maintained for nearly two days, after which the river gradually subsided to its normal level. The total discharge for the month of July, 1900, exceeded 19,000,000,000 cubic feet, and it may not be out of place to remark that had the proposed Mount Macdonald dam been in existence at the time there would have been sufficient water to fill the reservoir to overflowing, and allow a considerable volume to pass down the river to satisfy lower riparian holders, even after making a deduction for the contribution of streams which join the main river below the proposed dam site. The flood of

Flood of 1894. 1894, although not at any time reaching the maximum discharge recorded in July, 1900, was more sustained, as the river was in flood for four months of the year, and in that period no less than 66,600,000,000 cubic feet passed the Forbes gauging station. By way of comparison, it may be mentioned that this amount was 60 per cent. more than the volume discharged by the Murray at Albury for the whole of the year 1902, and, extending the comparison of yearly volumes, it is noticed that there were four years during the last decade when the mean annual volume discharged by the Murray at Albury was only slightly in excess of the volume that

Plate 33.



THE DARLING AT WILCANNIA (LOW RIVER).

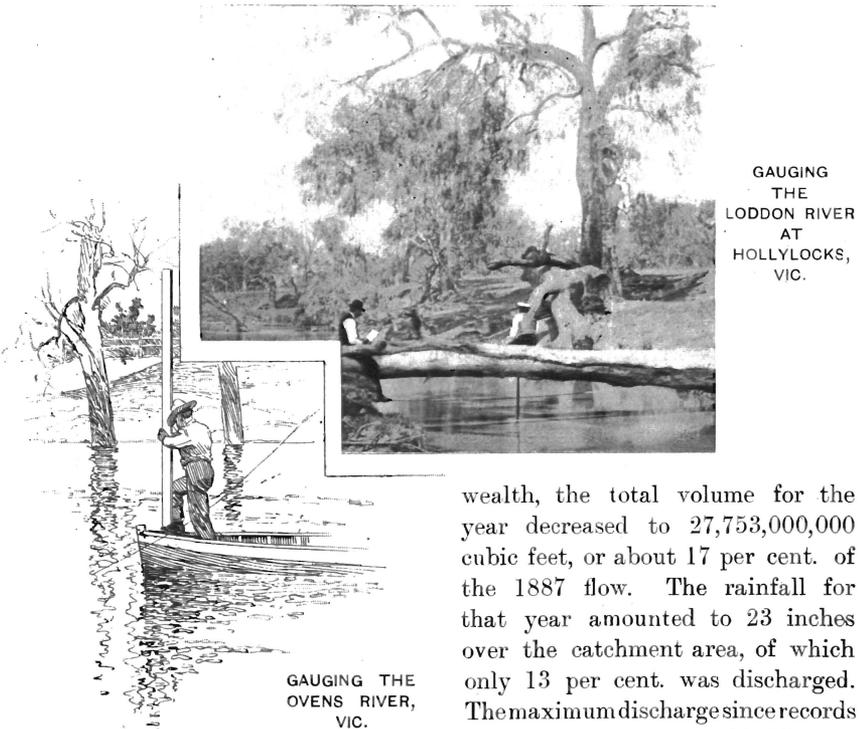
passed Forbes in the year 1894, namely, 92,600,000,000 cubic feet.

Drought of 1902. To see the other extreme of flow one must turn to the year 1902. The Lachlan during that year was little better than a chain of waterholes, and the discharge for the twelve months at Cowra only reached 1,024,000,000 cubic feet, of which a very small proportion passed Condobolin.

The most complete records of the Darling flow have been taken at Wilcannia (Plate 33). During the great flood of 1890 when a large quantity of tropical rain was precipitated on the immense gathering ground in Queensland, the discharge of the Darling reached its highest known point, viz.:—717,000,000,000 cubic feet. In 1902 the river was not running for eleven months, the discharge for the whole year only reaching the insignificant volume of 700,000,000 cubic feet. The lowest discharge previously recorded was in 1885, when the volume amounted to 20,000,000,000 cubic feet, or about thirty times that of 1902.

In the year 1887, 52 inches of rain fell on the catchment area of the Goulburn River of which 35 per cent. was discharged the volume passing the gauging station at Murchison being 168,000,000,000 cubic feet. This is the greatest observed annual discharge since gaugings were commenced. In 1902, in sympathy with the other rivers of the Common-

Plate 34.



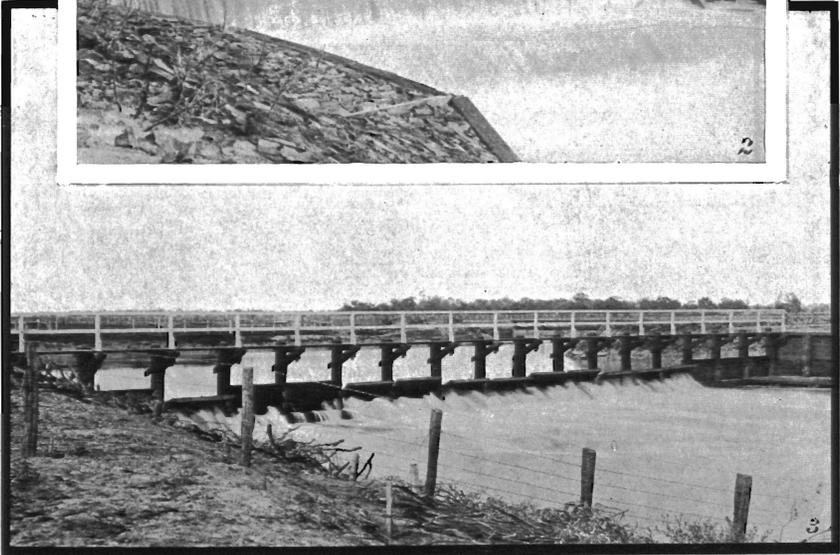
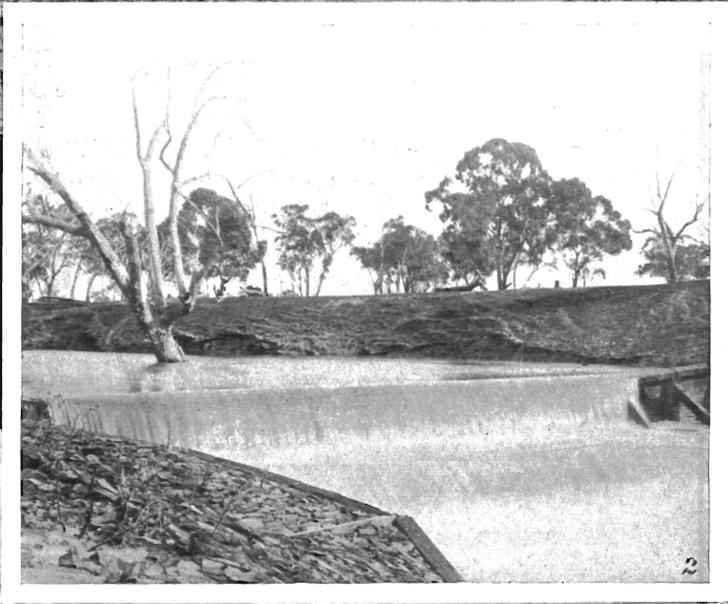
wealth, the total volume for the year decreased to 27,753,000,000 cubic feet, or about 17 per cent. of the 1887 flow. The rainfall for that year amounted to 23 inches over the catchment area, of which only 13 per cent. was discharged. The maximum discharge since records have been taken occurred in November, 1887, when the volume passing Murchison reached 1,923,330 cubic feet per minute. It is estimated, however, that the flood of 1870 was accountable for the discharge reaching the enormous volume of 2,750,000

cubic feet per minute. In contrast to these high gauge readings we turn to the abnormally low year of 1902, when the minimum discharge fell to 4,000 cubic feet per minute during the month of March, at Murchison.

The gaugings of the Ovens River were taken at Wangaratta township, a little below the junction of the King River, and therefore represent the combined flow of both rivers. **The Ovens, at Wangaratta.** In the year 1894 abundant rains fell on the gathering ground of the Ovens River and swelled the yearly volume to 82,948,000,000 cubic feet. The maximum discharge of 658,000 cubic feet per minute was recorded in the early spring of that year, when the melting snows of the Barry Mountains supplemented the copious rains. Towards the end of April last year the Ovens ceased running for a period of eighteen days, this being the first time ever recorded, and the volume for the whole year only amounted to 6,118,000,000 cubic feet, or a little more than one-third of the volume discharged in the month of September, 1894. The rainfall on the catchment of the Ovens River was 27 inches during the year 1902, but the fall was so intermittent in character and spread over such considerable periods that only 5 per cent. ran off.

The gaugings of the Mitta Mitta show that this river forms a very effective contributor to the waters of the Upper Murray. **The Mitta Mitta, at Tallangatta.** Like the Ovens, it reached its highest yearly volume in 1894, viz.: 87,987,000,000 cubic feet, representing 43 per cent. of the rainfall. In 1887, although the annual volume was less than that of 1894, the river reached its highest known discharge, viz.:—922,100 cubic feet per minute. Turning to the year 1902 it is found that the yearly volume fell to 12,581,000,000 cubic feet, or 14 per cent. of the 1894 flow. The lowest volume ever recorded passed the gauging station in January of this year, when 4,100 cubic feet per minute were discharged. Taking the period from 1886 to 1900, the mean annual discharge was about 54,000,000,000 cubic feet, so that the year 1902 may be considered as being 77 per cent. below the average. It is worthy of notice that although the rainfall for 1902 was 26 inches, or only 11 inches below the average for the fifteen years in question, the run off only represented 10 per cent.

The Kiewa River gaugings were commenced in 1885 and the highest recorded reading was in September, 1889. **The Kiewa River, at Kiewa.** The discharge corresponding to this reading was put down at 159,000 cubic feet per minute, being the best approximation deducible from the observed discharges at lower stages. The latter remark applies to nearly all the high discharges of other rivers mentioned in this paper. The total volume for the year 1889 was 27,121,000,000 cubic feet. A still higher annual volume of



IRRIGATION IN VICTORIA.

1. Inlet to Kow Swamp, National Works, Vic. 2. Coonoer Weir, Avoca River, Vic.
3. Flood Weir, Kow Swamp National Works, Vic.

29,506,000,000 cubic feet was recorded in 1894 when 68 inches of rain fell on the catchment area, of which 43 per cent. ran off. For the fifteen years from 1886 to 1900 the annual volumes were comparatively regular and represented an average of about 20,000,000,000 cubic feet; but in 1902, in common with the other rivers of the Murray basin, there was a marked falling off in the yearly total, which only reached 7,021,000,000 cubic feet, being 65 per cent. below the average. The lowest discharge, however, for any single day occurred in February, 1900, being 200 cubic feet per minute. As an illustration of the effective nature of the Kiewa gathering ground, it may be mentioned that although the rainfall for 1902 was 26 inches below the average for the period before mentioned, 23 per cent. of it passed the gauging station.

The evidence tendered to the Royal Commission on the Murray River should dispel the often expressed opinion that the State of Victoria contributes more largely to the flow of the Murray than New South Wales. On the Victorian side of the Murray the contributing area above Albury is double that of New South Wales, but the volume discharged by

Victorian and
New South Wales
contributions.

Plate 36.



MORNA ROCKS, LOWER MURRAY.

each State is almost equal, this being due to the fact that the New South Wales tributaries are fed from heavy deposits of snow, which melt in the spring and early summer. The Murrumbidgee in normal years also discharges more than the combined flow of the Ovens, Goulburn, Campaspe, and Loddon. The Darling, which is wholly within New South Wales and whose waters are almost entirely at the

disposal of South Australia, is a river of extremely irregular flow, yet in some years it can be relied on for a large accession to the flow of the Murray. The following table shows the relative contributions to the main stream by the States of New South Wales and Victoria :—

	High Year.	Low Year.	Mean Year.
	cubic feet.	cubic feet.	cubic feet.
New South Wales contribution	1,010,000,000,000	424,000,000,000	293,000,000,000
Victorian contribution	446,000,000,000	255,000,000,000	153,000,000,000
Proportion of total contributed by Victoria	29 per cent.	37 per cent.	34 per cent.

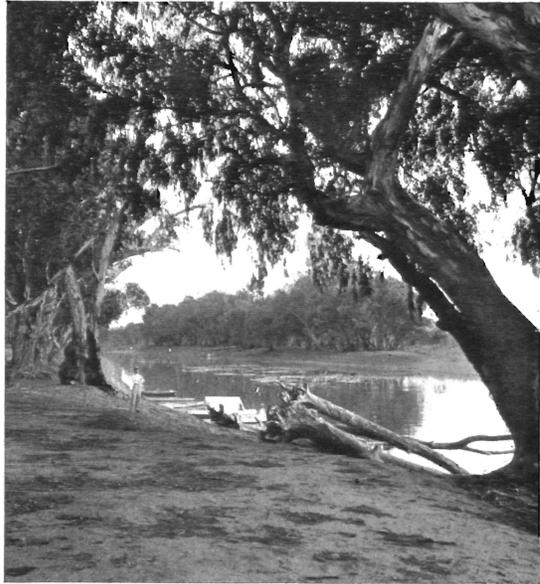
The above figures are based upon the gaugings taken for a number of years at the point of affluence with the Murray of the several contributing streams.

Referring to the question of gaugings, the following appears in the report of the Murray River Commission :—

“Of the rainfall precipitated on the drainage area or basin of a river, a portion is reabsorbed by evaporation into the atmosphere ; a portion descends through the permeable upper strata, to reappear in the form of springs, perhaps in the basin of some other river ; or finds its way to the sea through beds of deep-seated drift, or fissures and channels in the rock ; the balance is discharged through the river channel. The proportion of the

total rainfall on any drainage area that passes down its natural drainage line is extremely variable. It is greatest from those areas whose inclinations are steep, and in which the surface rocks are of compact and hard texture and but thinly covered with soil. And it is greatest in those seasons when the rains are heavy and the temperature low ; and least

Plate 37.



THE MURRAY RIVER, NEAR WENTWORTH, N.S.W.