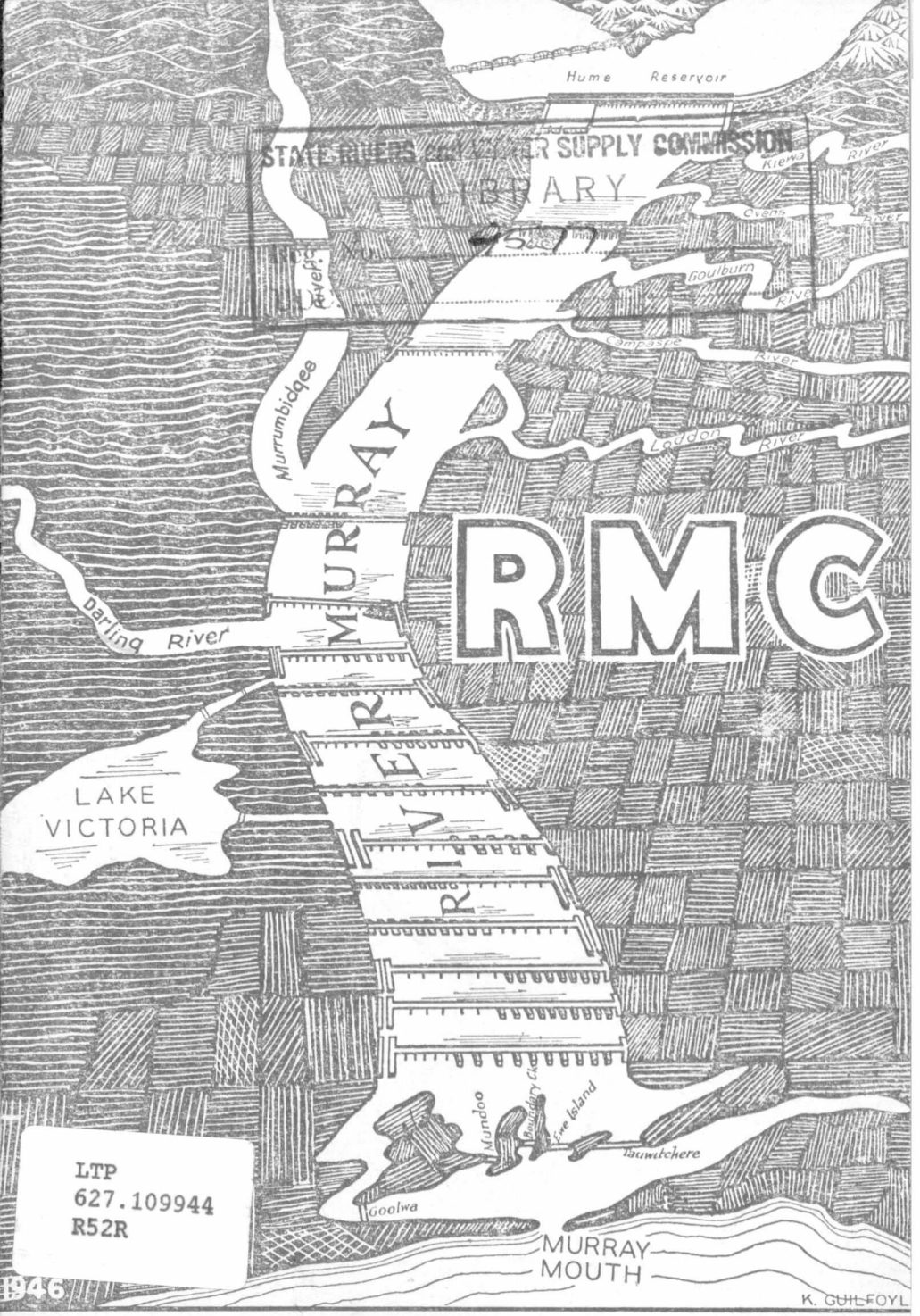

1946

THE WORK OF THE RIVER MURRAY COMMISSION

RIVER MURRAY COMMISSION

COMMONWEALTH

The Hon. N. Lemmon, M.H.R., President
C. A. Hoy, F.R.A.I.A., Deputy Commissioner

NEW SOUTH WALES

Frank H. Brewster

VICTORIA

L. R. East, M.C.E., M.Inst.C.E., M.Am.Soc.C.E., M.I.E.Aust.

SOUTH AUSTRALIA

J. H. O. Eaton, I.S.O., M.Inst.C.E., M.I.E.Aust.

R·M·C

HARNESSING AUSTRALIA'S GREATEST RIVER

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THE WORK OF THE RIVER MURRAY COMMISSION

1946

COMPILED BY
A. F. RONALDS, M.C.E., A.M.I.E.AUST.

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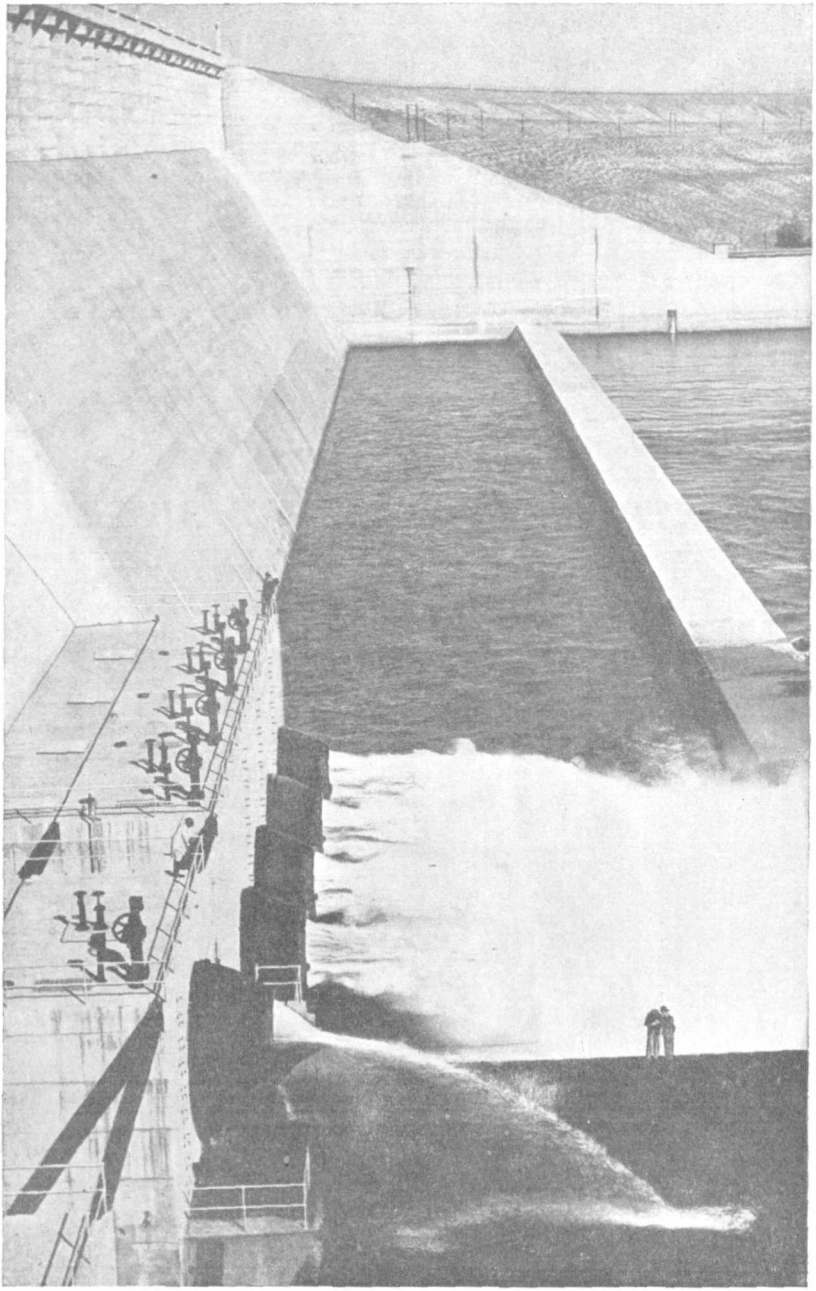
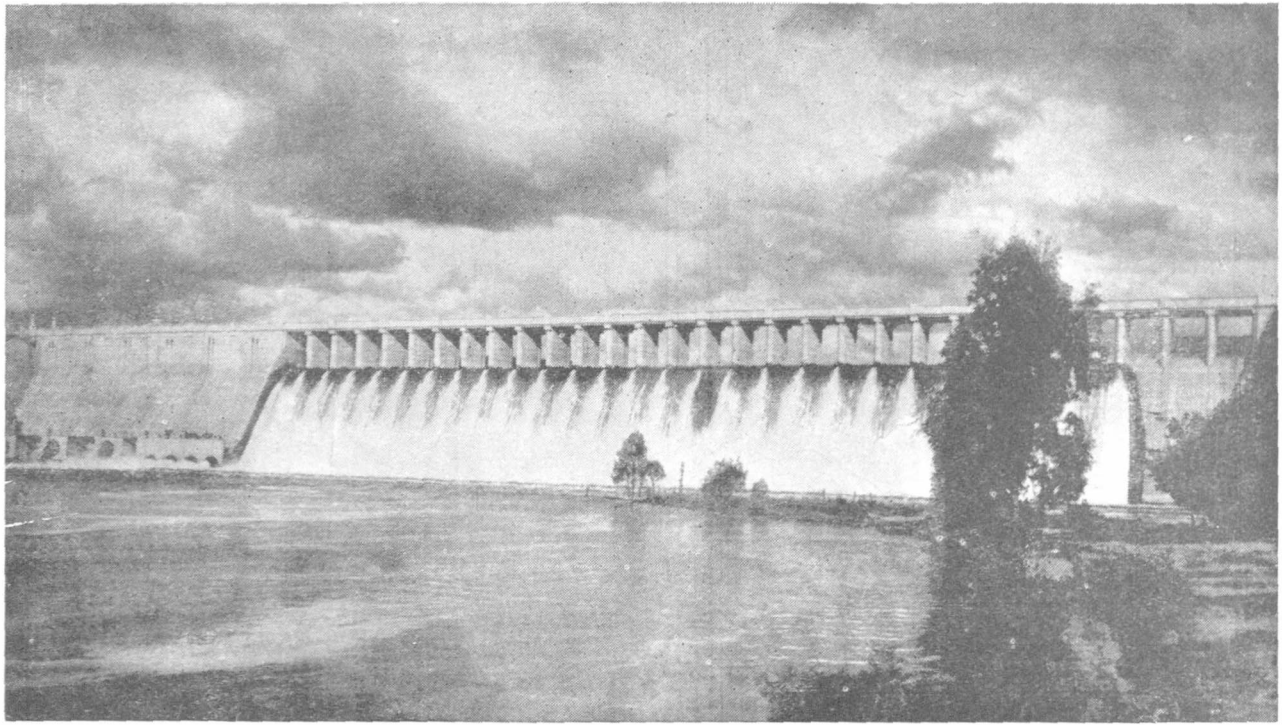
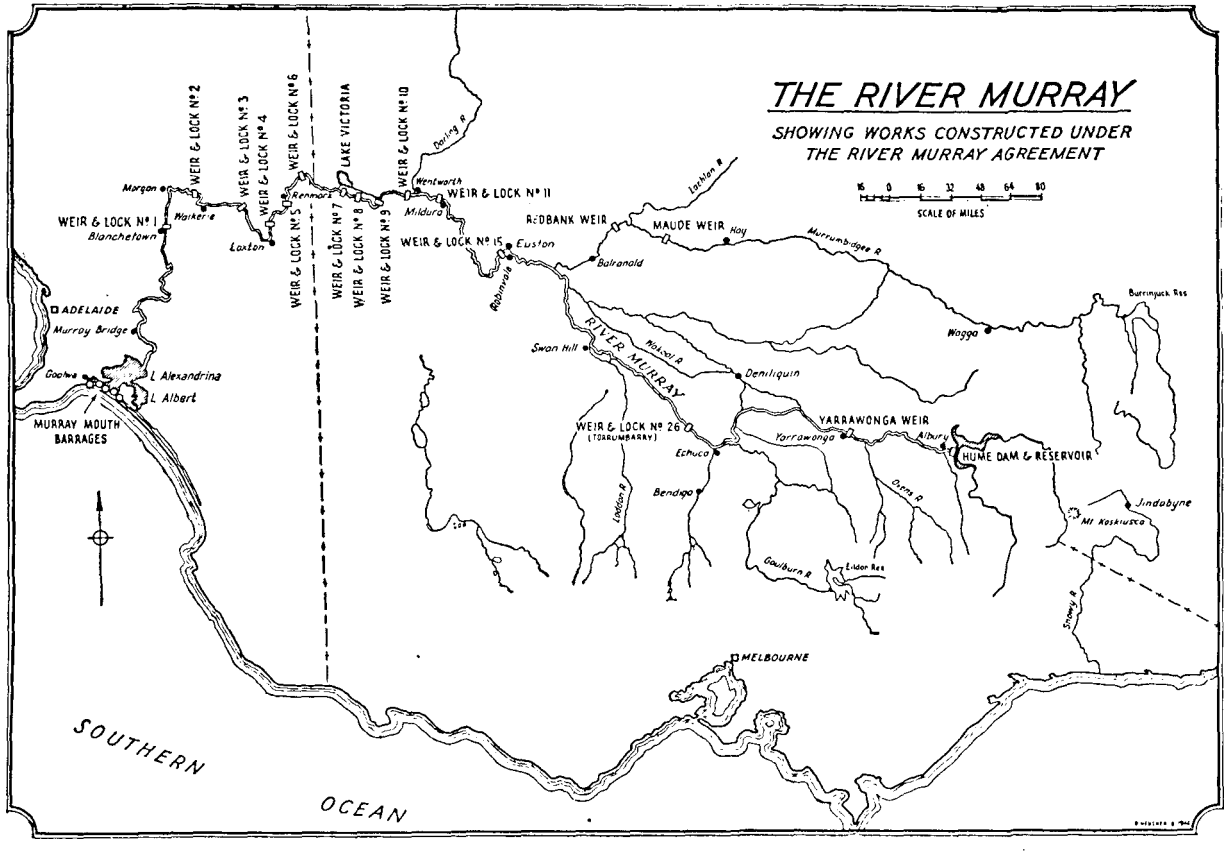
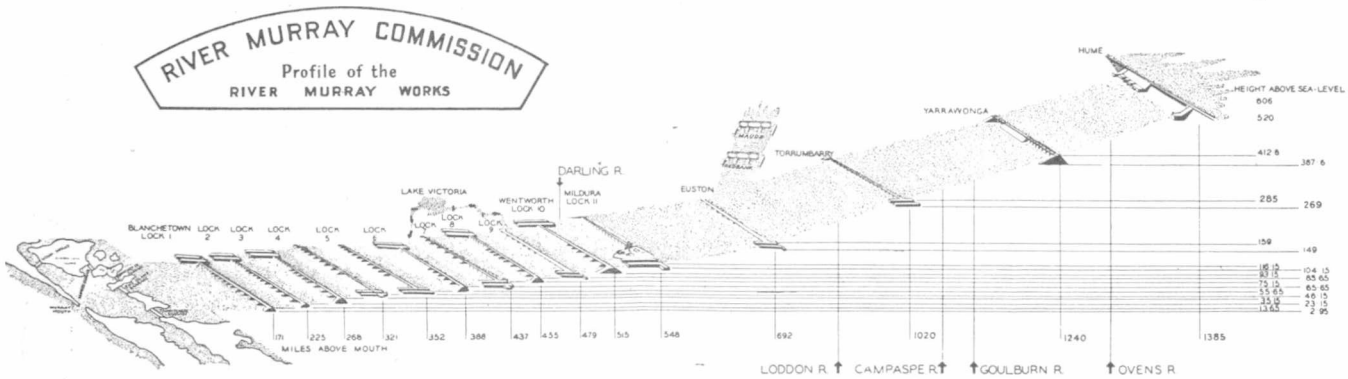


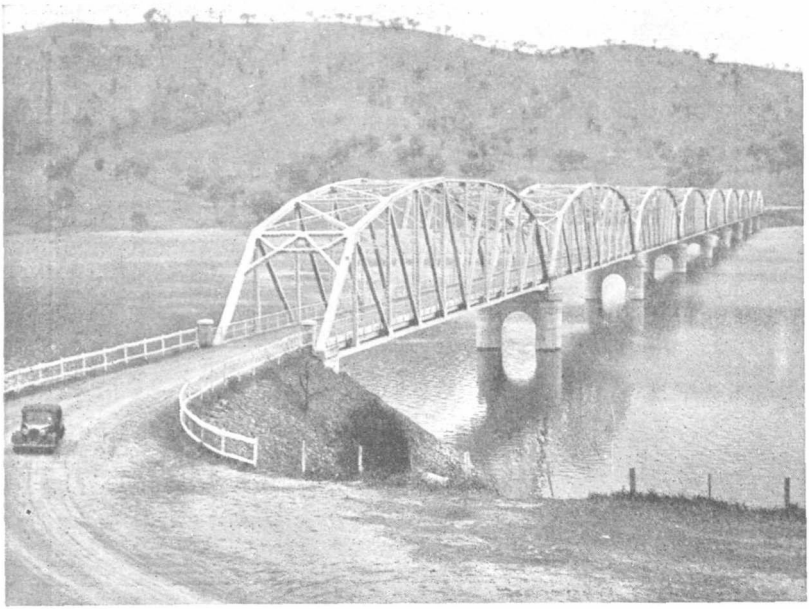
Hume Reservoir—Outlet Valves and Stilling Pool.



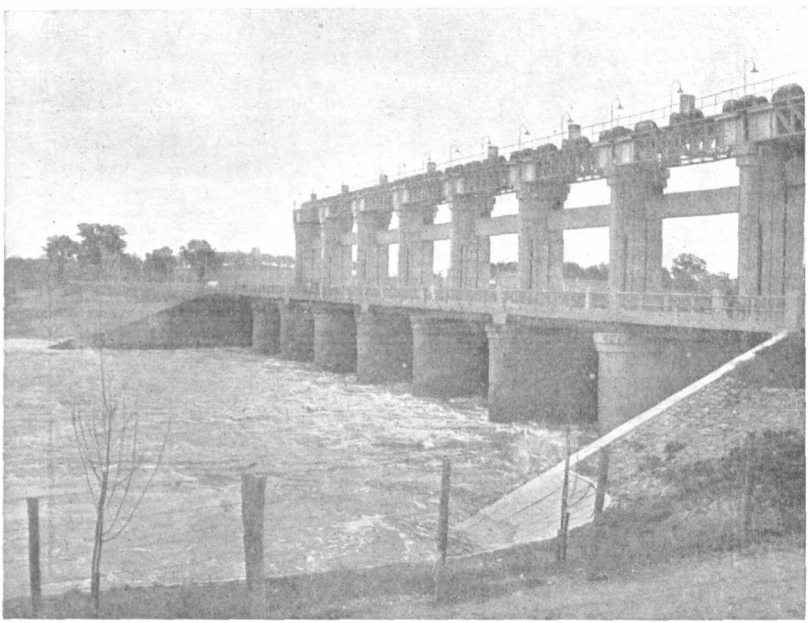
Spillway of Hume Dam.


THE RIVER MURRAY
SHOWING WORKS CONSTRUCTED UNDER THE RIVER MURRAY AGREEMENT
SCALE OF MILES
WEIR & LOCK Nº 1
WEIR & LOCK Nº 2
WEIR & LOCK Nº 3
WEIR & LOCK Nº 4
WEIR & LOCK Nº 5
WEIR & LOCK Nº 6
WEIR & LOCK Nº 7
WEIR & LOCK Nº 8
WEIR & LOCK Nº 9
WEIR & LOCK Nº 10
WEIR & LOCK Nº 11
WEIR & LOCK Nº 15
WEIR & LOCK Nº 26
(TORRUMBARRY)
REDBANK WEIR
MAUDE WEIR
YARRAWONGA WEIR
HUME DAM & RESERVOIR
LAKE VICTORIA
RIVER MURRAY
Blanchetown
Morgan
Walker's
Loxton
Renmark
Mildura
Wentworth
Euston
Robinvale
Balranald
Hay
Murrumbidgee R.
Lachlan R.
Darling R.
Burrinjuck Res.
Wagga
Albury
Yarrawonga
Deniliquin
Swan Hill
Wakool R.
Echuca
Bendigo
Loddon R.
Ovens R.
Goulburn R.
Eildon Res.
Mt Kosciusco
Jindabyne
Snowy R.
ADELAIDE
Murray Bridge
Goolwa
L. Alexandrina
L. Albert
MURRAY MOUTH BARRAGES
MELBOURNE
SOUTHERN OCEAN

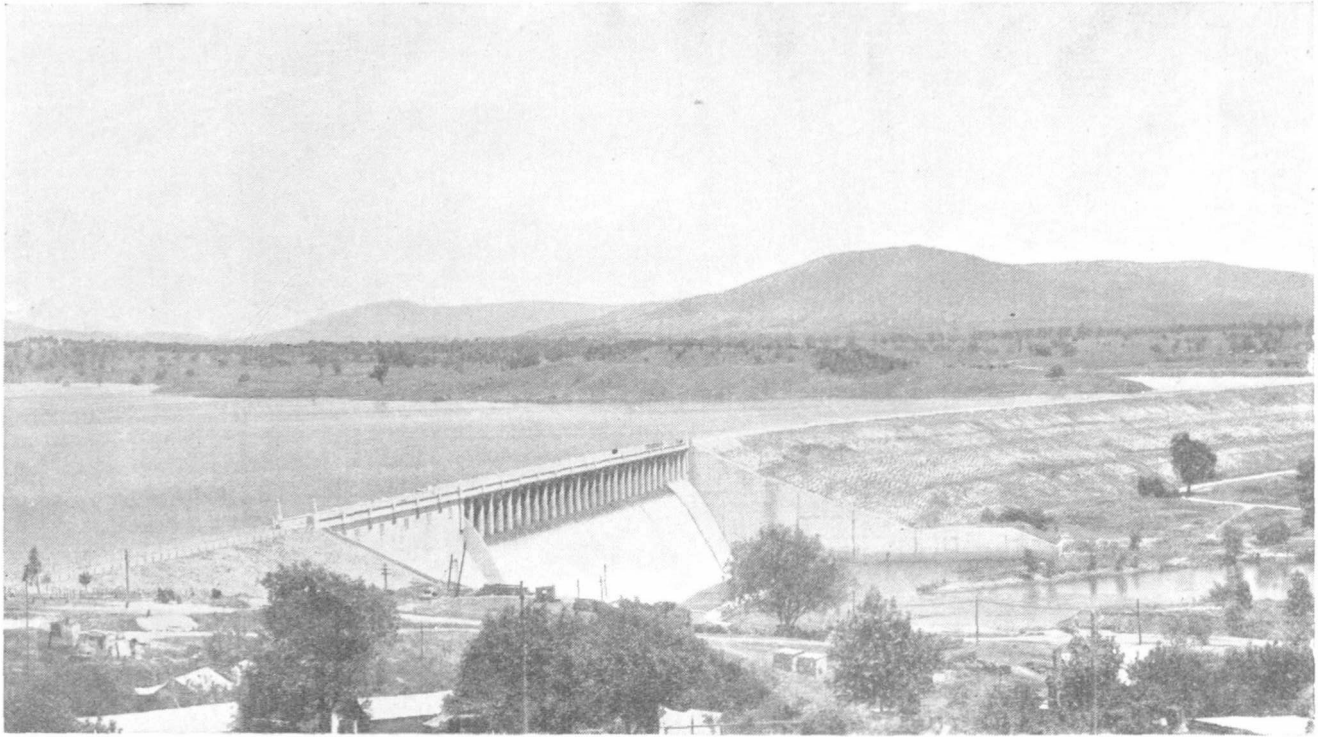

RIVER MURRAY COMMISSION
Profile of the
RIVER MURRAY WORKS
HUME
HEIGHT ABOVE SEA-LEVEL
606
520
YARRAWONGA
412 8
387 6
TORRUMBARRY
285
269
EUSTON
159
149
DARLING R.
MILDURA
LOCK 11
LAKE VICTORIA
WENTWORTH
LOCK 10
BLANCHETOWN
LOCK 1
LOCK 2
LOCK 3
LOCK 4
LOCK 5
LOCK 6
LOCK 7
LOCK 8
LOCK 9
171
225
268
321
352
388
437
455
479
515
548
692
1020
1240
1385
MILES ABOVE MOUTH
LODDON R.
CAMPASPE R.
GOULBURN R.
OVENS R.



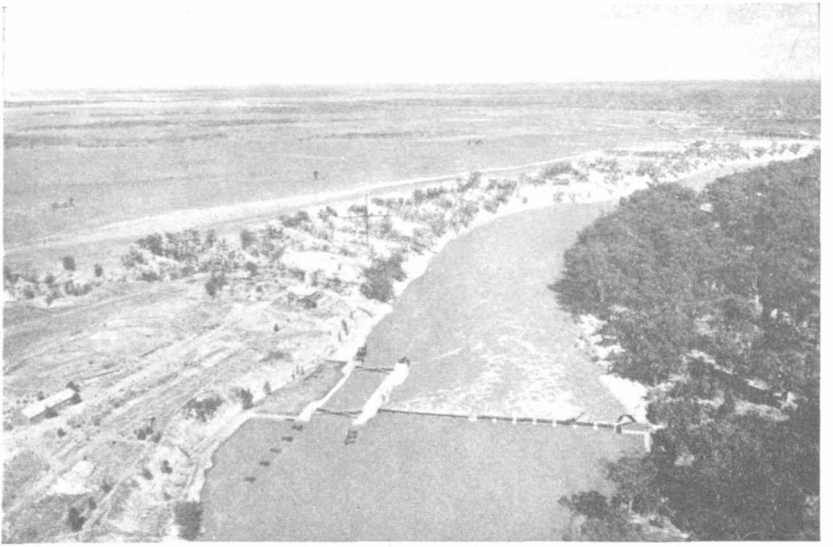
Bethanga Bridge—across the Murray Arm of the Hume Reservoir.



Yarrawonga Weir.

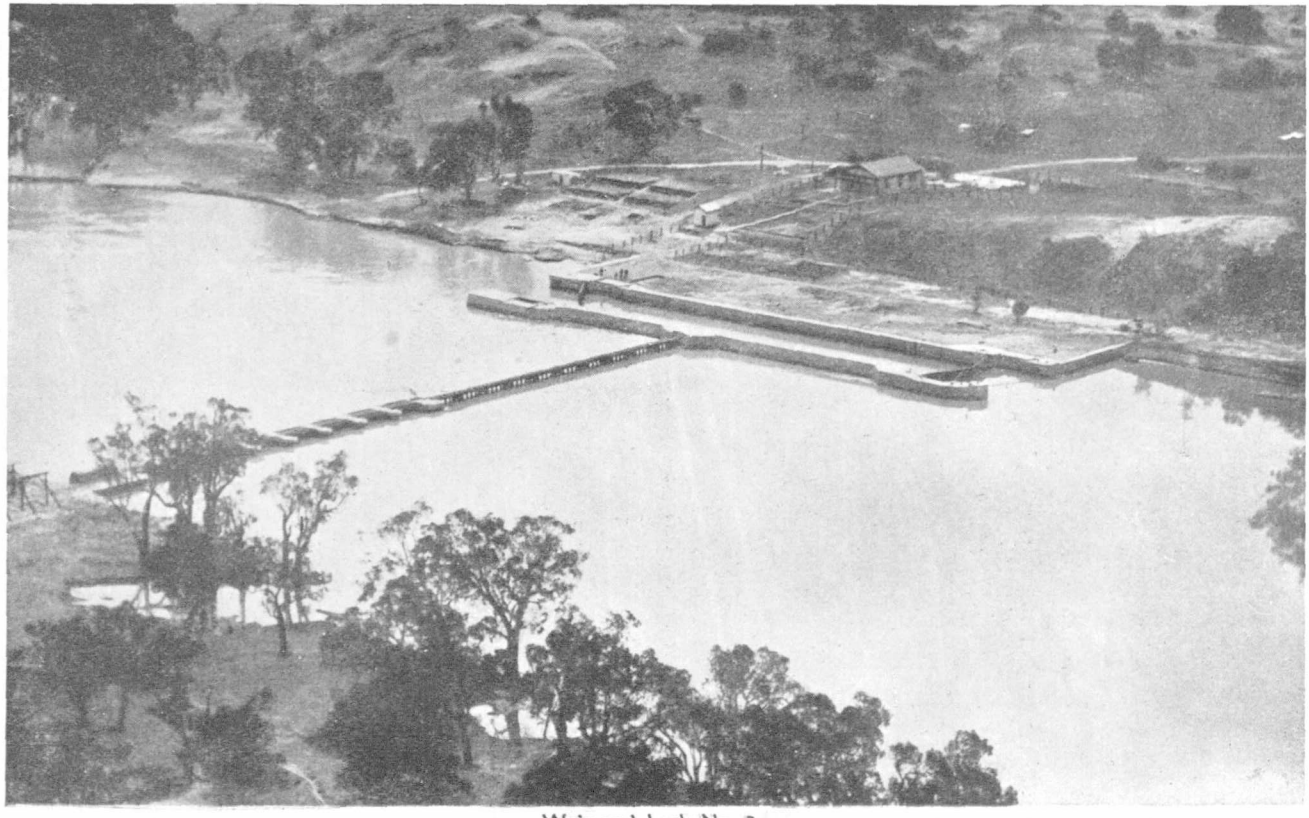


Hume Reservoir.

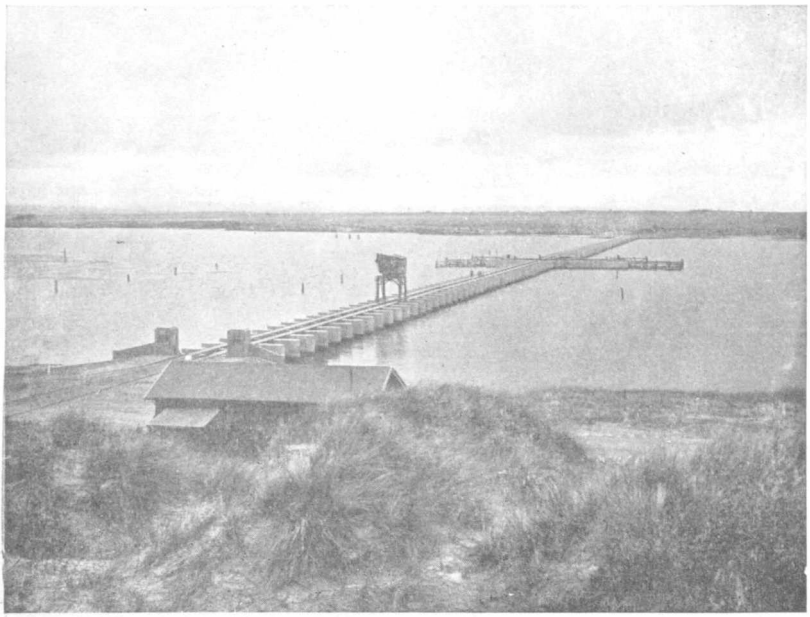


Weir and Lock at Euston.

A Trestle being withdrawn from the River
at the Mildura Weir.

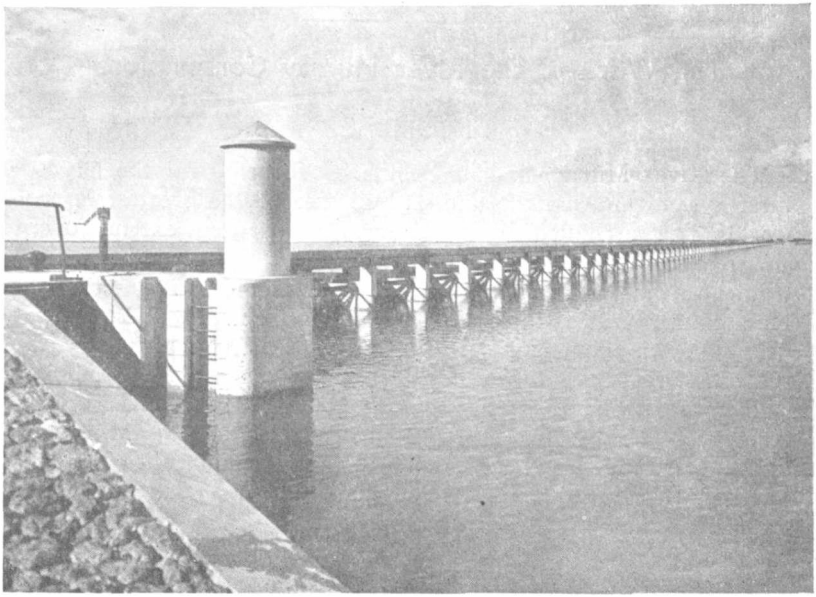


Weir and Lock No. 3.

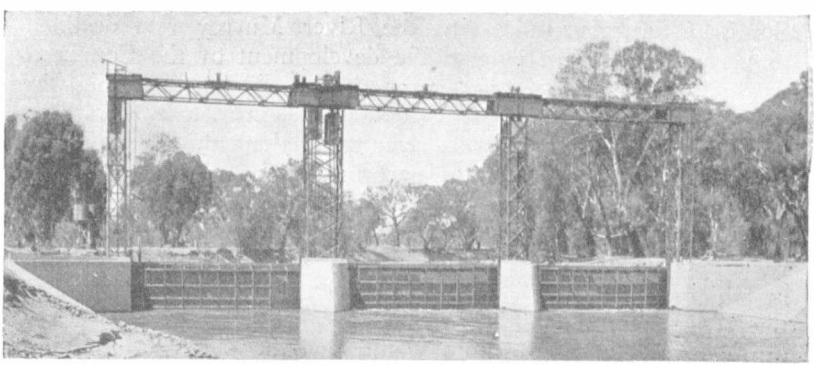


River Murray Barrages—General view of Goolwa Barrage.

Aerial view of Mundoo Barrage showing the Murray Mouth in the background.



Tauwitchere Barrage.



Maude Weir—Murrumbidgee River.

HARNESSING AUSTRALIA'S GREATEST RIVER.

The Work of the River Murray Commission.

HISTORICAL.

The River Murray and its tributaries form by far the largest river system in Australia and, indeed, one of the greatest in the world. The catchment of the River Murray system extends over an area of 414,000 square miles, or about one-seventh of the whole of the Australian Continent, and includes five-sixths of New South Wales, over one-half of Victoria, a small portion of South Australia, and an area of Queensland which exceeds the total area of Victoria. The length of the Murray from its source to its mouth is about 1,600 miles (1,366 miles below Albury). The Darling is 1,760 miles in length, the Murrumbidgee 1,050 miles, and the Goulburn, another important tributary of the Murray, 280 miles. The main streams contributing to the Murray flow are:—

Stream.	Average Annual Flow.
Upper Murray, including the Mitta and Kiewa Rivers	3,400,000 acre feet.
Murrumbidgee River	2,600,000 acre feet.
Goulburn River	2,250,000 acre feet.
Darling River	2,150,000 acre feet.
Ovens River	1,200,000 acre feet.

(An acre foot of water is the volume required to cover one acre to a depth of one foot—or 272,250 gallons.)

It was evident, even in the early days of the development of South-Eastern Australia, that the River Murray was destined to play an important part in the development of the Commonwealth. In the early stages a good deal of consideration was given to the possibilities of navigation and, in fact, in the 1850's began a period of prosperous river trade along the Murray, and this played a very important part in opening up settlement of large areas in New South Wales, Victoria, and South Australia. Navigation, however, was intermittent because of the great variations in the flows of the Murray and its tributaries from month to month and from year to year, due to the fact that at times the river would be in flood because of extremely heavy rainfalls, and at other times would dwindle almost to nothing as a result of droughts.

As far back as 1863, proposals were made for the improvement of the River Murray System, and at that time New South Wales, Victoria, and South Australia at a conference in Melbourne favoured the locking of the main stream, principally for navigation, and, in the early 1870's, efforts were made to devise a scheme for this purpose. About that time, however, Victoria commenced irrigating from the Murray and it became apparent by 1880 that irrigation would, in the future, seriously restrict navigation because of the diversions of water from the Murray by the three States adjoining its banks. It was found impossible at that time to devise a basis for the equitable distribution of the waters of the Murray and its tributaries amongst the three States concerned; but in 1902, as a result of public opinion, an Interstate Royal Commission was appointed to inquire and report "concerning the conservation and distribution of the waters of the Murray and its tributaries for the purpose of irrigation, navigation, and water supply."

The report of that Commission is a most valuable reference to many aspects of irrigation in Australia. However, the diversity of interests of the States still prevented any agreement being reached with respect to the harnessing of the river and the diversion of its waters, and it was not until 1914, following upon a report of an Interstate Conference of Engineers in 1913, that full agreement was reached on this most controversial matter.

This agreement, which forms the basis of the work of the River Murray Commission, was ratified by the River Murray Waters Act in the Parliaments of the Commonwealth and the States of New South Wales, Victoria, and South Australia in 1915, and may be said to have anticipated by nearly twenty years the setting up of the Tennessee Valley Authority in the United States of America. The River Murray Agreement was the initiation of a new and prosperous era for the Murray Basin, and only to-day are the people of Australia beginning to appreciate the full significance of the work of the River Murray Commission.

RIVER MURRAY AGREEMENT.

The River Murray Agreement, which was incorporated in the 1915 Acts, provided for the construction of works, the allocation of the water between the three States concerned, and the appointment of the River Murray Commission to give effect to the Agreement.

The works to be carried out consisted of two large storages, one on the Upper Murray above Albury, and the other at Lake Victoria near the South Australian boundary, together with 26 weirs and locks in the Murray between its mouth and Echuca, and nine weirs and locks on the Murrumbidgee, or, alternatively, on the Darling. The choice between these two streams rested with New South Wales, wherupon the Murrumbidgee was selected.

The River Murray Commission under the Agreement is not a constructing authority, its responsibility being to arrange for the construction of the works by existing State Authorities, namely, the Department of Public Works, New South Wales; the State Rivers and Water Supply Commission, Victoria; and the Engineering and Water Supply Department, South Australia. The constructing authorities in each case have been responsible for the design and construction of the works allotted to them, subject to the approval and direction of the River Murray Commission, and are responsible also for the continued maintenance of those works.

With regard to the distribution of waters between the three States, the Agreement provides that the minimum quantity of water to be allowed to pass for supply to South Australia in each year shall be sufficient to fill Lake Victoria storage once, and, with the aid of water returned from Lake Victoria, to maintain certain specified flows in the lower river varying from 47,000 acre feet per month in the winter months, to 134,000 acre feet per month in the four summer months of maximum demand—the total amounting to 1,254,000 acre feet over the twelve months. These flows are to meet the domestic and stock requirements of South Australia, losses of water in the locks and evaporation losses other than in the lakes at the Murray mouth, together with 603,000 acre feet per annum for diversion from the Murray for the use of irrigators in South Australia.

The flow of the Murray at Albury is shared equally by New South Wales and Victoria, and each of these States has full control of its tributaries below Albury, subject in each case to the meeting of the South Australian allocation set out above.

The Agreement then goes on to provide that, after the utilization for irrigation from the River Murray and its tributaries in any year by New South Wales of 1,957,000 acre feet or by Victoria of 2,219,000 acre feet or by South Australia of 603,000 acre feet, a further volume or volumes may be allotted from time to time by the River Murray Commission out of any surplus flows which may exist.

Realizing that there would be periods of severe drought when the flows would be insufficient to meet the full quantities allocated to the States, provision was made in the Agreement for the River Murray Commission to vary the allocations during such periods, to give proportionately reduced supplies to each State.

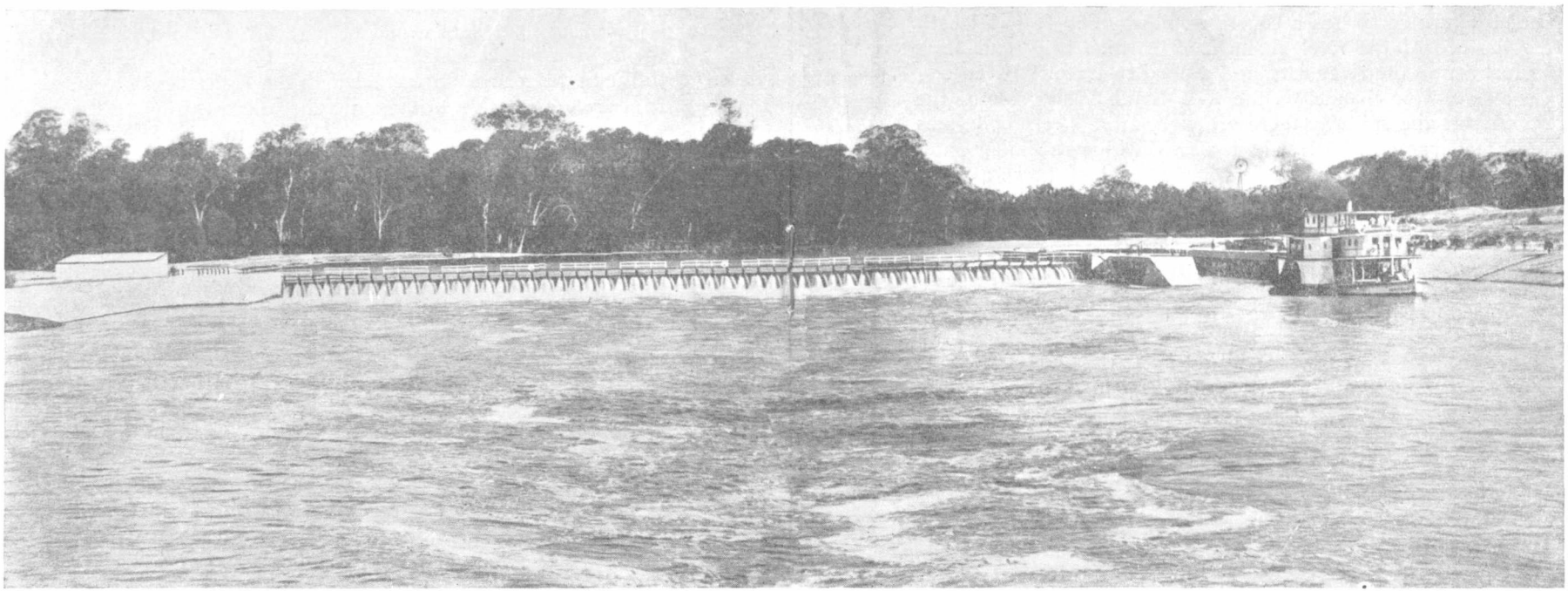
As the recording of stream flows is, of course, a vital requirement in the regulation of outflows from the storages and in the determination of diversions by the States, the River Murray Commission is required under the Agreement to establish uniform gauging systems and, so far, some 44 stations are in operation for this purpose.

In 1934 the Agreement was varied to provide for the construction of a diversion weir on the River Murray at Yarrawonga, and of barrages at the mouth of the Murray to prevent salt water from the sea entering the lakes at the Murray mouth and the lower section of the river in South Australia. The 1934 amendment also limited the original proposal of 26 weirs and locks on the Murray and 9 on the Murrumbidgee to 13 on the Murray and 2 on the Murrumbidgee. At that time the capacity of Hume Reservoir was limited to 1,250,000 acre feet, with a provision that work carried out then would enable the capacity of the reservoir to be increased to 2,000,000 acre feet later, if this further action were decided upon. As a result of the 1934 amendment of the Agreement permanent navigation on the Murray is limited to a stretch of about 600 miles between the mouth of the river and some 50 miles above Mildura, where the river traffic consists, at present, of a small tourist trade.

The River Murray Commission, which administers the River Murray Agreement, comprises four Commissioners representing respectively the Commonwealth of Australia and the States of New South Wales, Victoria, and South Australia. The Commonwealth representative presides at all meetings of the Commission.

HUME DAM.

The major work carried out under the direction of the River Murray Commission was the construction of the concrete and earth embankment of the Hume Reservoir, the largest water storage in the Southern Hemisphere. The dam, which is situated just below the junction of the Upper Murray and Mitta Mitta Rivers some 10 miles above Albury, holds back a body of water



Torrumbarry Weir and Lock.

100 feet high backing up the valley of the Murray for 40 miles and up the valley of the Mitta Mitta for some 20 miles, forming a great inland lake with an area of 33,000 acres—about three times the surface area of the Sydney Harbour. Before the dam was constructed the site was, of course, thoroughly tested by putting down more than 150 bores across the river valley and, by this means, it was ascertained that a bed-rock of grey granite could be reached at an average depth of 34 feet below the surface of the flat, this rock being overlaid by varying thicknesses of decomposed granite, and layers of sand, gravels, and alluvium.

On the New South Wales side, at the site of the Dam, the river was confined by a steep bank, whilst on the Victorian side there was an extensive flat half a mile wide, and which was subject to flooding during periods of high river.

The design adopted for the construction of the Dam included a mass concrete spillway and outlet works extending 1,000 feet across the river, a short earthen embankment on the New South Wales side, and a great earthen dam averaging 100 feet in height and extending across the flats for 4,000 feet to the hills on the Victorian side—the total length of the whole structure being

just over one mile. The bank contains 4,200,000 cubic yards of earth-fill, and the spillway 564,000 cubic yards of concrete.

This great engineering work was completed in 1936, giving a capacity to the Reservoir of 1,250,000 acre feet, the limit authorized under the 1934 Amendment of the River Murray Agreement.

The release of water from the Hume Reservoir is controlled by seven 7 ft. 6 in. diameter outlet valves, which, with a full reservoir, are capable of discharging a total flow of 20,000 cubic feet of water per second, or 7,500,000 gallons per minute. These valves are operated by electric power, generated by a small hydro-electric turbine, three of the valves having provision for large hydro-electric turbines, which, when the power generating station is erected, will generate electric power to link up with and supplement the national electric power systems.

YARRAWONGA WEIR.

On the River Murray some 145 river miles below the Hume Dam, at the town of Yarrawonga, is situated a diversion weir known as the Yarrawonga Weir, which was completed in 1939.

The structure comprises a concrete spillway 380 feet in length across the bed of the river channel, an earthen bank extending 1,125 feet across the river flats, and a flood regulator 99 feet long across an overflow channel on the New South Wales side of the river. Across the spillway there are eight large steel flood gates each 40 feet long and 20 feet high which, with two similar gates across the flood regulator, enable water to be held up to a depth of approximately 50 feet. These gates are operated electrically for the regulation of the flow and can be raised clear of flood levels. The embankment across the flats has an average height of 22 feet.

The purpose of the weir is to raise the water level in the river to a height sufficient for its diversion, by gravitation, into main irrigation channels on both sides of the Murray. The channel on the New South Wales side, known as Mulwala Canal, has a capacity, at the offtake, of 2,500 cubic feet per second, and will serve 1,000,000 acres of land in New South Wales. On the Victorian side the diversion channel, known as the Yarrawonga Canal, has a capacity, at the offtake, of 1,250 cubic feet per second and will serve some 270,000 acres, although only portion of both these areas will actually be irrigated.

The weir, which has brought into being Lake Mulwala containing 95,000 acre feet of water, is another picturesque monument to the work of the River Murray Commission.

WEIRS AND LOCKS.

Between the Yarrawonga Weir and the Murray mouth, the River Murray Commission has constructed a series of thirteen weirs and locks, the primary purpose of which is to aid navigation and facilitate irrigation. Two weirs have also been constructed on the Murrumbidgee River below Hay. In general these weirs and locks consist of a series of concrete buttresses carrying large-size timber stop planks across portion of the width of the stream, and a series of hinged steel trestles across the remainder. These trestles carry timber panels to hold back the water, and when these panels are removed, as during the periods of high river, the trestles can be lowered flat on the bed of the stream to provide a clear waterway. Normally the trestles are maintained in an upright position, when all river traffic must pass through a lock chamber constructed at one end of the weir. The operation of this lock enables vessels to pass from the lower level below the weir to the higher level upstream, or vice versa. The lock chamber

at each of the ten structures below Mildura, is 275 feet long and 56 feet wide, the three upper structures having somewhat smaller lock chambers, each 170 feet long and 56 feet wide.

These weirs and locks form a continuous series of pools from the Murray mouth to Mildura, the difference in water level at each structure varying from 8 ft. 6 in. to 12 feet, with an average of about 10 feet.

Of the thirteen weirs and locks, however, two, situated on the Murray at Mildura and at Torrumbarry, 46 river miles downstream from Echuca, are of a type quite different from the others—a type evolved in Australia by the late J. S. Dethridge, M.Inst.C.E., who was the Victorian representative on the River Murray Commission from its inception until his death in 1926.

The Dethridge Weir, like the South Australian weirs, is carried on a reinforced concrete foundation, but the steel trestles, unlike the South Australian hinged trestles, are provided with wheels on which they can be drawn out of the stream in times of flood. A great advantage of this type is that painting and repairs to steelwork can be carried out while the trestles are out of the stream. When in position in the river timber drop bars are laid against the steel trestles to raise the water level to the required height.

The two Murrumbidgee weirs are at Redbank, 20 miles below the Lachlan Junction, and at Maude, 40 miles above the Lachlan Junction. They are used as flood diversion weirs to divert flood waters on to extensive areas, on both banks of the river, which would otherwise be inundated only during isolated periods of very high flood. This periodic artificial flooding, which covers an area of 350,000 acres of grazing land, has greatly increased the carrying capacity of this land. These two weirs, which are of very similar design each consisting of a low concrete sill surmounted by three large movable steel flood gates between piers and abutments, were completed in 1940.

LAKE VICTORIA STORAGE.

On the north side of the River Murray in New South Wales, 35 miles downstream from the Darling River Junction, and in the vicinity of the South Australian border, the River Murray Commission has constructed a second storage known as Lake Victoria. This storage is actually a large natural basin improved

by the construction of embankments and control regulators, making possible a storage of 551,700 acre feet of water for use in the South Australian irrigation settlements. It has an area of 27,670 acres.

The lake is filled from the Murray through a channel some twenty miles in length, portion of which is in a natural waterway, known as Frenchman's Creek. To prevent flood waters entering the lake, except through the channel, a number of embankments had to be provided along the sides of the channels, and these, together with the bank around the lake itself, have a total length of 32 miles. These works were completed in 1928.

Weir and Lock No. 9 on the River Murray is used to raise the river level to a height sufficient to pass water by gravitation through the channel to Lake Victoria, the channel having a capacity of 1,700 cubic feet per second.

Water released from Lake Victoria re-enters the Murray through a short stream known as Rufus River. This re-entry takes place below Weir and Lock No. 7, thus giving a fall from entry to outlet of 27 ft. 6 in.

MURRAY MOUTH BARRAGES.

The main purpose of the barrages at the Murray mouth is to prevent the ingress of salt water from the sea during periods of low river, and to maintain, as far as possible, the freshness of the water in Lakes Alexandrina and Albert, and thus improve and maintain the productivity of the surrounding areas which were becoming injuriously affected after prolonged periods of salinity in the lakes. The structures also have the effect of maintaining a sufficiently high level in the river for some 50 miles above the lake to permit of the watering by gravitation of a number of areas of reclaimed river flats.

There are five barrages constructed across channels connecting Lake Alexandrina with the sea, and they are situated at a sufficient distance from the open sea to minimize the risk of damage during heavy storms which frequently occur along that coast.

The Goolwa Barrage, which crosses the main channel, consists of a concrete floor carried on hundreds of piles and surmounted with concrete piers which carry Jarrah stop logs. The top timbers are removed when the lakes are full, and it becomes necessary to release water from the lakes to the sea. The structure is provided with a lock chamber for passing pleasure and fishing

boats, also a navigable pass for steamers. The Mundoo and Boundary Creek barrages are of similar type to that at Goolwa, except that they are built on a limestone reef which obviated the necessity for piles. They are also in shallower water.

The Ewe Island and Tauwitchere barrages on the eastern side are of a different type from the others. They consist mainly of an earthern embankment, but each contains a section of radial or sector gates for regulating the flow of water through the barrages. These gates, built of steel, are hinged between concrete piers 14 feet apart, the piers in turn resting on a concrete floor.

The gates, of which there are 433 in the two structures, are raised when it is necessary to pass flood waters to the sea.

The combined length of the structures is 5 miles, Tauwitchere Barrage being by far the longest with a length of 2¼ miles. Vehicles can cross the barrages, but owing to the decking being of sufficient width for one vehicle only, the crossing is not a public road. The total distance across the barrages and the intervening islands is some 15 miles. The works were completed in 1940.

COST OF RIVER MURRAY WORKS.

All works authorized under the 1934 amendment of the River Murray Agreement have now been carried out—the total cost of their construction being just under £12,000,000, almost one-half of which was spent on the Hume Reservoir This expenditure was shared equally by the Commonwealth and each of the three States.

The cost of maintenance, operation, and control of the River Murray works is divided equally between the three States, the Commonwealth being free from any liability in this direction.

RESERVOIR SILTATION AND CATCHMENT PROTECTION.

During the early stages of the construction of the Hume Reservoir the River Murray Commission realized that, if the reservoir were to have a long and useful life, erosion on the catchment area would have to be arrested and, if possible, eliminated altogether. As far back as 1925, the Commission asked the Governments of New South Wales and Victoria to take such action as would "effectively prevent the destruction of forests as far as Crown lands and leaseholds were concerned."

In 1932, several years before the Hume Reservoir was completed, the Commission commenced a regular system of observations from which to determine the rate of siltation in the reservoir.

A thorough investigation of the position, based on these observations, was made in 1945, and indicated that the total siltation in the thirteen years since 1932 was about 6,000 acre feet. This volume represents one two-hundredth part of the capacity of the reservoir or an average of less than $2\frac{1}{4}$ inches over the whole of the 33,000 acres covered by the reservoir.

While this rate of siltation is comparatively low—in fact much lower than in many large reservoirs in other countries—it points to the fact that the useful life of the reservoir does depend on the degree of soil erosion on the catchment and that every effort should be made to reduce this to a minimum. Of more importance still is the fact that, during heavy rains following bad droughts and bush fires, the rate of siltation is many times that of a normal year.

It is well known that the continued existence of conditions which are conducive to soil erosion will result in a rapid extension of erosion, also that erosion is much easier to prevent than cure. The main cause of soil erosion is the destruction of vegetative cover by bushfires, rabbits, and unwise land management. Where soil erosion has once started the forces of nature cause it to spread rapidly. Fortunately, in the Hume Catchment the degree of erosion is comparatively small but its presence is indeed a warning that must be heeded.

Since 1925, considerable attention has been given to the preservation of the Hume Catchment of 6,000 square miles, much of which is more or less mountainous. Although New South Wales and Victoria have achieved much in the way of catchment protection on the areas within their respective States by fire prevention measures and steps to preserve timber on Crown lands and to prevent overgrazing, the Governments concerned are now giving consideration to proposals made by the Commonwealth for more effective control of the catchment by one responsible authority.

The permanent preservation of the Hume Catchment will have a two-fold effect. It will maintain the usefulness of a great water storage, and will insure that the catchment can continue in production, both from an agricultural and a grazing point of view. If, however, action were not taken for the preservation of the catchment, not only would the wealth obtained from the wise use of the land disappear, but the water storage itself would, in time, be so affected by silt as to lose a great measure of its usefulness.

IRRIGATION DEVELOPMENT.

To get a complete picture of water conservation and distribution in the Murray Basin it should be realized that, in addition to works carried out by the River Murray Commission, the separate States have constructed thousands of miles of water distribution channels and provided a number of storages on tributaries of the Murray. The main tributary storages are as follows—

Storage.	Capacity. Acre Feet.
Burrinjuck Reservoir on the Murrumbidgee River ..	771,600
Wyangala Reservoir on the Lachlan River	304,000
Eildon Reservoir on the Goulburn River	306,000
Waranga Basin adjoining the Goulburn River ..	333,400

The River Murray works and those constructed by the States in the Murray Basin have resulted in very great development of lands which, without the advent of water, would have yielded a very much smaller contribution to Australia's national primary wealth.

Irrigation production is mainly in the form of dried and fresh fruits, dairy produce, wool, fat lambs, rice, vegetables, poultry, eggs and pigs and, to some extent, beef cattle.

The diversions from the River Murray and its tributaries for irrigation purposes for the year ending June, 1945, and the areas irrigated were as follows:—

State.	Diversion. Acre Feet.	Area Irrigated. Acres.
New South Wales ..	817,384 ..	365,000
Victoria	1,775,493 ..	610,000
South Australia	190,371 ..	41,000
Totals ..	2,783,248 ..	1,016,000

The value of production from these areas has been estimated at about £18,000,000 per annum, apart from the greatly increased value of many of the products after they have been processed or manufactured into consumer goods. Without irrigation, the value of production from these areas would probably be well under £2,000,000 a year.

To provide for further development in irrigation, which is playing such an important part in the country's economic life, the Commonwealth and State Governments have been giving

consideration to the completion of the Hume Reservoir, to its designed capacity of 2,000,000 acre feet, and to the enlargement of the inlet channel to Lake Victoria which is necessary to permit greater storage in Lake Victoria of periodic flood flows of short duration. It is hoped that these very important additions to water conservation in the Murray Basin will soon be effected.

An idea of the enormous amount of water which 2,000,000 acre-feet, or one filling of the completed Hume Reservoir, represents may be gained from the fact that it is equal to 544,500,000,000 gallons or sufficient to meet the whole requirements of a city of 1,000,000 people—cities like Sydney and Melbourne—for twenty years.

A GREAT NATIONAL ASSET.

The real wealth of any country can be measured only by its production. The prosperity of a people depends upon the development of the country's resources, and the utilization of the natural water resources of the Murray Basin by conservation and scientific application to the land in the form of irrigation, represents one of the greatest sources of wealth we have in Australia.

The works so successfully carried out under the River Murray Agreement form vital links in the water conservation and irrigation systems of the vast Murray Basin which, it is well to note, is some ten times greater than the area controlled by the Tennessee Valley Authority.

We can look upon the works of the River Murray Commission as a very fine example of effective co-operation between the Commonwealth and the States functioning through their respective State Departments, and what has been achieved in this direction, can be done in other fields throughout Australia.

It is estimated that the Murray Basin—one seventh of the Commonwealth—produced last year almost one-half of the total rural primary production and one-third of the total exports of all products from Australia. In Victoria alone, by means of irrigation, less than two per cent. of the total area of the State contributes fifteen per cent. of the total primary production. It will be seen, therefore, that the works of the River Murray Commission, together with the works of the Water Conservation and Irrigation Commission, New South Wales; the State Rivers and Water Supply Commission, Victoria; and the Engineering and

Water Supply Department, South Australia, have played and are destined to play in the future, a most important part, not only in the development of land in the Murray Basin, but in the future prosperity of the Commonwealth. As a result of wise water conservation, the lands in the Murray Basin will continue to increase in national value, and will absorb an increasing number of people who will be able to attain a standard of living not possible in those areas without the harnessing of the waters of the Murray and its tributaries.

A paddle steamer on the River Murray.

PARTICULARS OF STORAGES.

HUME RESERVOIR.

Catchment area	6,000 sq. miles
Capacity	1,250,000 ac. ft. (2,000,000)
Crest of earthen embankment above river flats—	
Average	100 ft.
Maximum	128 ft.
Top water level above river bed	106 ft. (126 ft.)
Height of top water level above sea level	606 ft. (626 ft.)
Area of reservoir at top water level	33,000 acres (44,000 acres)
Length of reservoir—	
Murray arm	39 miles (50 miles)
Mitta arm	21 miles (25 miles)
Length of concrete spillway and outlet works (N.S.W.)	1,042 ft. 6 in.
Length of earth embankment (N.S.W.)	430 ft. 6 in.
Length of earth embankment (Victoria)	3,827 ft.
Total length	5,300 ft.
Quantity of concrete in dam	564,000 c. yds.
Quantity of earthwork in dam	4,200,000 c. yds.
Number of regulating gates	(29)
Size of regulating gates	(20 ft. long by 15 ft. high)
Date of completion to 1,250,000 acre feet storage	1936

Note.—Figures in brackets refer only to a storage of 2,000,000 acre feet.

LAKE VICTORIA.

Total capacity	551,700 ac. ft.
Volume below gravity draw-off level	34,000 ac. ft.
Area of lake at top water level	27,670 acres
Depth of water	24 ft.
Height of top water level above sea level	91·15 ft.
Total lengh of earthen embankment	32 miles

Lake filled through Frenchman's Creek from pool above Weir and Lock No. 9 on the River Murray.

Outlet from Lake is through Rufus River, which discharges into the River Murray below Weir and Lock No. 7.

Lake Victoria works completed in 1928.

WEIRS.

Name.	Mileage.	Upper Pool Level (feet above sea level).	Construction Completed.	Type of Structure.
Yarrawonga (River Murray) ..	1,240 miles from Murray mouth ..	412·80	1939	Concrete overflow weir with eight 40 ft. x 20 ft. steel gates and a subsidiary channel with two 40 ft. x 20 ft. steel gates
Redbank (Murrumbidgee River)	120 miles upstream from the junction with the Murray River	223·50	1940	Concrete structure with three 56 ft. x 18 ft. 6 in. steel lifting gates
Maude (Murrumbidgee River)..	180 miles upstream from the junction with the Murray River	250·75	1940	Concrete structure with three 56 ft. x 18 ft. 6 in. steel lifting gates

WEIRS AND LOCKS.

No.	Name.	Mileage from the Murray Mouth.	Lower Pool Level (feet above sea level).	Upper Pool Level (feet above sea level).	Length of Weir (not including lock) (feet).	Type of Weir.	Construction Completed.
1	Blanchetown	171	2·95	13·65	554	Boule	1922
2	.. ..	225	13·65	23·15	454	Boule	1928
3	.. ..	268	23·15	35·15	404	Boule	1925
4	.. ..	321	35·15	46·15	409	Boule	1929
5	.. ..	352	46·15	55·65	409	Boule	1927
6	.. ..	388	55·65	65·65	284	Boule	1930
7	.. ..	437	65·65	75·15	274	Boule	1934
8	.. ..	455	75·15	83·65	389	Boule	1935
9	.. ..	479	83·65	93·15	309	Boule	1926
10	Wentworth	515	93·15	104·15	384	Boule	1929
11	Mildura	548	104·15	116·15	573	Dethridge	1927
15	Euston	692	149·00	159·00	299	Boule	1937
26	Torrumbarry	1,020	269·00	285·00	327	Dethridge	1924

MURRAY MOUTH BARRAGES.

—	Goolwa Channel Barrage.	Mundoo Barrage.	Boundary Creek Barrage.	Ewe Island Barrage.	Tauwitchere Barrage.
Total length of barrage ..	2,075 ft.	2,600 ft.	800 ft.	7,450 ft.	12,000 ft.
Number of openings ..	128	26	6	111	322
Length of each opening ..	11 ft. 9 in.	11 ft. 9 in.	11 ft. 9 in.	12 ft. 8 in.	12 ft. 8 in.
Type of opening	Stop logs	Stop logs	Stop logs	Radial gates	Radial gates
Size of lock	100 ft. x 20 ft.	..	..	..	45 ft. x 12 ft. 6 in.
Navigable pass	67 ft. 9 in.	..	..	..	..
Number of timber piles ..	4,770	..	..	..	..
Concrete	17,720 c. yds.	2,948 c. yds.	449 c. yds.	4,216 c. yds.	12,755 c. yds.
Earth embankments ..	..	17,450 c. yds.	5,123 c. yds.	47,750 c. yds.	67,600 c. yds.
Stone protection	24,450 c. yds.	8,610 c. yds.	9,714 c. yds.	19,711 c. yds.	30,145 c. yds.

Works completed 1940

COST OF RIVER MURRAY WORKS AS AT 30TH JUNE, 1946.

	£
Hume Reservoir	5,489,816
Bethanga Bridge	208,411
Yarrawonga Weir	586,761
Torrumbarry Weir and Lock	285,516
Euston Weir and Lock	416,634
Weir and Lock No. 11—Mildura	365,181
Weir and Lock No. 10—Wentworth	397,815
Weir and Lock No. 9	326,482
Weir and Lock No. 8	229,856
Weir and Lock No. 7	273,837
Weir and Lock No. 6	258,714
Weir and Lock No. 5—Renmark	329,750
Weir and Lock No. 4	289,654
Weir and Lock No. 3	259,951
Weir and Lock No. 2	284,643
Weir and Lock No. 1—Blanchetown	264,501
Lake Victoria Storage	495,207
Murray Mouth Barrages	751,248
Murrumbidgee Weirs—	
Maude	143,724
Redbank	132,012
Surveys, special investigations, gauging stations, &c.	100,668
	£11,890,381

MILEAGES OF MAIN TOWNS, WEIRS AND LOCKS, ETC.

Miles.	
0	Murray Mouth.
5	Goolwa Barrage.
7½	Goolwa.
48	Wellington.
55½	Tailem Bend.
70½	Murray Bridge.
94	Mannum.
153	Swan Reach.
170¾	Weir and Lock No. 1—Blanchetown.
199	Morgan.
206	Cadell.
225¼	Weir and Lock No. 2.
238	Waikerie.
264½	Overland Corner.
268½	Weir and Lock No. 3.
271¼	Kingston.
281	Moorook.
304¼	Loxton.
321	Weir and Lock No. 4.
327	Berri.
351½	Weir and Lock No. 5.
352½	Paringa Bridge.
354¾	Renmark.
388	Weir and Lock No. 6.
398¾	Victorian and South Australian Border.
405¾	New South Wales and South Australian Border.
437	Weir and Lock No. 7, Rufus River junction, outlet from Lake Victoria.
455	Weir and Lock No. 8.
468	Ned's Corner.
479	Weir and Lock No. 9.
484¼	Frenchman's Creek, inlet to Lake Victoria.
515	Weir and Lock No. 10—Wentworth, junction with Darling River.
548	Weir and Lock No. 11—Mildura.
692	Weir and Lock No. 15—Euston.
770	Murrumbidgee junction.
800	Wakool junction.
840	Nyah.
875	Swan Hill, Loddon River junction.
920	Murrabit.
945	Koondrook.
1,020	Weir and Lock No. 26—Torrumbarry.
1,030	Offtake channel to Torrumbarry Irrigation System.
1,066	Echuca, Campaspe River junction.
1,076	Goulburn River junction.
1,096	Barmah.
1,180	Tocumwal.
1,197	Cobram.
1,240	Yarrawonga Weir.
1,262	Ovens River junction.
1,297	Corowa.
1,366	Albury.
1,385	Hume Reservoir, junction with Mitta Mitta River.

FACTS ABOUT THE MURRAY.

The first indication of an inland water system in Australia was the discovery of the headwaters of the Lachlan and Macquarie rivers by George William Evans in 1815.

The River Murray was first seen by white men—the explorers Hume and Hovell—on the 16th November, 1824, just downstream from where Hume Dam now stands.

In 1830 Captain Sturt and a small party of men rowed a boat down the Murray from a point on the Murrumbidgee near Maude through unknown country to the sea and then back, a distance of 1,700 miles—truly a remarkable feat.

Sturt named the River Murray after Sir George Murray, then Colonial Secretary—the ceremony taking place at the junction of the Darling River on the 23rd January, 1830.

In 1853 the first paddle steamers navigated the Murray. In that year, Captain Cadell in the *Lady Augusta* and Captain Randell in the *Mary Ann* steamed up the river from Goolwa to Swan Hill.

Shortly afterwards Captain George Johnston took the steamer *Albury* to where that city now stands—1,366 miles from the sea.

The Murray-Darling river combination, extending a total distance of 3,282 miles from the sea, is the fourth longest in the world—being exceeded only by the Nile (4,000 miles), the Mississippi-Missouri (3,988 miles), and the Amazon (3,900 miles).

The grade or fall of the Murray varies from 9 inches per mile near Albury to about 1 inch per mile in the last 100 miles to the sea.

The flow in the Murray at Albury takes about one month to reach South Australia, and the flow in the headwaters of the Darling takes two months or more to reach the Murray.

At Wentworth, 515 miles from the river mouth, the river is 104 feet above sea level; at Echuca, 1,066 miles, the river is 285 feet above sea level; and at Albury, 1,366 miles, it is 500 feet above sea level.

The highest point of the Murray Basin watershed is Mt. Kosciusko with an altitude of 7,328 feet.

The area of the lakes at the Murray mouth are Lake Alexandrina, 224 square miles, and Lake Albert, 64 square miles.

The average annual rainfall over the Murray Basin is 17 inches, compared with an average of about 50 inches in the Tennessee Valley, U.S.A.

Of the area of 414,000 square miles in the Murray Basin only about 21,000 square miles, or 5 per cent. of the total area, has an average rainfall in excess of 30 inches.

The catchment of the upper Murray above Albury contributes more than one-quarter of the total flow in the Murray system, from an area of 6,400 square miles, which is less than 2 per cent. of the total catchment area.

Regular gaugings of the flow in the River Murray were commenced in 1865, many years before regular gaugings were initiated on most important streams in other countries.

The average flow of the River Murray and all its tributaries is some 12,000,000 acre-feet a year—suffic whole basin to a depth of half an inch only, and represe lowest run-off from any large river system in the world.

Since gaugings commenced at Swan Hill in 1909, the Murray ceased to flow at that point for short periods in 1914, 1915, and 1923. In April, 1915, no flow was recorded for the whole month—the river being reduced to a chain of water holes.

Since Hume Reservoir was constructed, a flow has been maintained throughout the length of the Murray at all times, despite several severe drought periods.

By Authority: J. J. Gourley, Government Printer, Melbourne.

More detailed information in regard to the harnessing of the River Murray is included in the following publications—

A SHORT HISTORY OF THE RIVER MURRAY WORKS

by

J. H. O. Eaton,

I.S.O., M.Inst.C.E., M.I.E.Aust.

Adelaide *Government Printer* *1945*

THE LIFE OF GEORGE CHAFFEY

by

J. A. Alexander

Melbourne *Macmillan & Co. Ltd.* *1928*

WATER INTO GOLD

by

Ernestine Hill

Melbourne *Robertson & Mullens* *1937*