

CHAPTER XXIII.

WATER CONSERVATION AND IRRIGATION.

§ 1. Artesian Water.

1. **General.**—In every country in which droughts are recurrent, there are few problems the solution of which is of greater importance than that of an adequate system of water conservation. Much has been done in Australia so far as the supply of water to centres of population is concerned, and a description of several of the metropolitan water works will be found herein, viz., in the chapter dealing with Local Government. Interstate Conferences on artesian water were held in 1912, 1914, and 1921, when combined Governmental action was agreed upon with reference to delimitation of the artesian basins, hydrographic surveys, analyses and utilization of artesian water, etc. (See map on page 897.)

2. **The Great Australian Artesian Basin.**—In speaking of the "Great Australian Artesian Basin," the area is understood which includes (a) considerably more than one-half of Queensland, taking in practically all that State lying west of the Great Dividing Range, with the exception of an area in the north-west contiguous to the Northern Territory; (b) a considerable strip of New South Wales along its northern boundary and west of the Great Dividing Range; and (c) the north-eastern part of South Australia proper, together with the extreme south-eastern corner of the Northern Territory. This basin (shown approximately by the map on page 897) is said to be the largest yet discovered, and measures about 602,000 square miles, of which 376,000 square miles are in Queensland, 118,000 square miles in South Australia, 83,000 square miles in New South Wales, and 25,000 square miles in the Northern Territory. The area of the intake beds is estimated at 60,010 square miles, viz., 50,000 square miles in Queensland and 10,010 square miles in New South Wales. A description of the basin and its geological formation will be found in previous issues of the Year Book (see No. 6, p. 569).

3. **The Western Australian Basins.**—The Western Australian Basins fall naturally within five distinct groups, viz., the Eucla Basin, in the extreme south-east of the State, extending well into South Australia along the shores of the Great Australian Bight; the Coastal Plain Basin, west of the Darling Range; the North-West Basin, between the Murchison and Ashburton Rivers; the Gulf Basin, between Cambridge Gulf and Queen's Channel; and the Desert Basin, between the De Grey and Fitzroy Rivers.

The Recent and Tertiary strata which enter Western Australia at its eastern border, and which have a prevailing dip towards the Great Australian Bight, form the Eucla artesian water area. Where boring operations have been undertaken, the water has been found to be salt or brackish, and there are other conditions affecting the supply, such as local variations in the thickness of the beds, their relative porosity, and the unevenness of the floor upon which they rest, which, so far, have not been examined with sufficient thoroughness to enable many particulars to be given in regard to this basin.

In the Coastal Plain Basin to the west of the Darling Ranges artesian boring has, on the other hand, been carried on successfully for many years.

4. **The Murray River Basin.**—The Murray River basin extends over south-western New South Wales, north-western Victoria, and south-eastern South Australia. It is bounded on the west by the azoic and palæozoic rocks of the Mount Lofty and other ranges, extending northwards from near the mouth of the Murray to the Barrier Ranges, and on the east and north-east by the ranges of Victoria and New South Wales. This tertiary water-basin is occupied by a succession of sedimentary formations, both porous and impervious. It is of interest to note that the waters of the Murray River are partly

supplied by influx from the water-bearing beds of this basin; this is proved by the fact that, at low water, springs are observed at certain places flowing into it from beneath the limestone cliffs from Pyap Bend downwards. Similar springs exist along the courses of other branches of the River Murray system, where they cut through the tertiary formation. On the Victorian side bores have been put down, and water has been struck at various levels.

5. **Plutonic or Meteoric Waters.**—In previous Year Books will be found a statement of the theory of Professor Gregory* as to the origin of the water in the Australian artesian basins together with the objections held thereto by a former Government Geologist of New South Wales.† (See Year Book No. 6, p. 570.)

6. **Artesian and Sub-Artesian Bores.**—(i) *General.* The following table gives particulars of artesian and sub-artesian bores in each State and in the Northern Territory :—

ARTESIAN AND SUB-ARTESIAN BORES, 1921–22.

Particulars.	N.S.W.	Victoria.	Q'land.	S. Aust. (c)	W. Aust.	N. Ter. (e)	Total.
Bores existing .. No.	507	337	2,829	146	182	159	4,160
Total depth bored .. feet	845,652	91,361	d3,521,978	114,625	164,984	47,158	4,785,758
Daily flow .. ,000 gals.	a84,590	b	a393,073	a13,204	56,206	f	b
Depth at which artesian water was struck—							
Maximum .. feet	4,338	700	6,000	4,850	c 2,275	1,760	6,000
Minimum .. feet	89	150	10	55	c 39	60	10
Temperature of flow—							
Maximum .. °Fahr.	140	b	210	208	c 140	b	210
Minimum .. °Fahr.	72	b	81	82	c 75	b	72

(a) Flowing bores only. (b) Not available. (c) Government bores only. (d) Total depth of all bores. (e) 1920–21 figures. (f) Average pumping supply 32,000 gallons per day.

(ii) *New South Wales.*—(a) *Artesian Water Supply.* The New South Wales portion of the great Australian basin, comprising approximately 83,000 square miles, is situated in the north-western portion of the State. Artesian boring in New South Wales dates from 1879, when a private bore was put down on the Kallara pastoral holding, between Bourke and Wilcannia. The first Government bore was that at Goonery, on the Bourke-Wanaaring road, completed in 1884.

The following statement shows the extent of the work successfully carried out by the Government and by private owners up to 30th June, 1922 :—

EXISTING ARTESIAN BORES.—NEW SOUTH WALES, 1922.

Bores.	Flowing.	Pumping.	Total.	Total Depth.
For Public Watering-places, Artesian Wells, etc. ..	125	36	161	332,858
For Country Towns Water Supply ..	3	1	4	6,533
For Improvement Leases ..	34	3	37	58,412
Total Government Bores ..	162	40	202	397,803
Private Bores	223	82	305	447,849

* See J. W. Gregory, F.R.S., D.Sc.: "The Dead Heart of Australia," London, John Murray, 1906; "The Flowing Wells of Central Australia," Geogr. Journ., July and August, 1911.

† E. F. Pittman, A.R.S.M., formerly Government Geologist of New South Wales: "Problems of the Artesian Water Supply of Australia, with special reference to Professor Gregory's Theory," (Clarke Memorial Lecture, delivered before the Royal Society of New South Wales, 31st October, 1907); "The Great Australian Artesian Basin," Sydney, 1914; "The Composition and Porosity of the Intake Beds of the Great Australian Artesian Basin," Sydney, 1915.

The average depth is 1,969 feet in the case of Government bores, and of private bores 1,468 feet, and it ranges from 89 to 4,338 feet. The two deepest wells in New South Wales are those at Boronga, in the County of Stapylton, with a depth of 4,338 feet and a present outflow of 908,090 gallons; and at Dolgelly, in the Parish of Carennaga, in County Stapylton, with a depth of 4,086 feet, and a present discharge of 534,406 gallons per day. The largest flow at the present time is that at the Wirrah bore, in the County of Benarba, which yields 1,062,123 gallons a day, and has a depth of 3,578 feet.

Of the 555 bores which have been sunk, 385 are flowing, and give an aggregate discharge of 84,589,733 gallons per day; 122 bores give a pumping supply, the balance of 48 being failures; the total depth bored represents 906,594 feet.

The flow from 79 bores is utilized for supplying water for stock on holdings served in connexion with Bore Water Trusts or Artesian Districts under the Water Act of 1912. The total flow from these bores amounts to 34,712,398 gallons per day, watering an area of 4,556,024 acres by means of 2,820 miles of distributing channels. The average rating by the Bore Trusts to repay the capital cost with 4 per cent. interest in twenty-eight years, is 1.5d. per acre, including the cost of maintenance and administration.

In the majority of cases the remaining bores are used by pastoralists for stock-watering purposes only, but in a few instances the supply is utilized in connexion with country towns.

The watering of the north-western country by means of bore water has largely increased the carrying capacity of the land; and, what is of perhaps greater importance, it has made comparatively small pastoral holdings practicable in country previously confined almost entirely to the operations of companies holding immense areas.

It having been determined that multiplicity of bores is the chief factor governing the annual decrease in bore flows, and also that limiting the discharge from a bore will prolong its flowing life, action has been taken to prevent any waste by controlling the bore flow to actual requirements. It is confidently anticipated that this action will materially reduce the rate of decrease in the future.

(b) *Private Artesian Bores.* Much has been done in the way of artesian boring by private enterprise. As far as can be ascertained, 329 private bores have been undertaken in New South Wales, of which 24 were failures. The yield of the flowing bores is estimated at 37.3 million gallons per day. No data are available regarding the pumping bores.

(c) *Shallow Boring.* The scheme described in Official Year Book No. 9 (p. 520) for assisting settlers by sinking shallow bores has met with considerable success.

Operations commenced with one plant only, but the number has been increased gradually until 28 plants are at work.

A large number of applications from settlers wishing to take advantage of the liberal conditions offered under the regulations has been received, and further applications are coming to hand daily, consequently the plants now in use will probably be insufficient to cope with the demand. Out of 950 bores put in hand up to 30th June, 1922, 175 have proved failures.

There can be no question that the added value of the holdings represented by the bores already put down is considerably in excess of their cost, and as fairly conclusive evidence of this, it might be stated that in several instances the Government Savings Bank has, on completion of a bore, made the settler a sufficient advance to enable him to pay the total cost in cash.

In addition to the work carried out under the Shallow Boring Regulations outlined above, shallow boring plants have sunk 22 bores in the Pilliga scrub and on Crown lands for the Lands and Forestry Departments.

The fact that of the bores put down in the Pilliga scrub, 52 are giving a flowing supply, adds much to their value, and is of special interest as indicating the possibility of tapping a small and hitherto unknown artesian basin.

(iii) *Victoria.* Victoria lies altogether outside the Great Australian Artesian Basin, and as water is generally available from surface or shallow underground supplies, there has not been much occasion for artesian boring. As early as 1880, however, an artesian well

was bored at Sale, which gave a large supply of water of fair quality before it failed through corrosion of the casing. In 1905 a new bore was put down, which at a depth of 277 feet yielded sufficient water to fill Lake Guthridge, a local depression. As the water was, however, impure, and contained an excess of sulphuretted hydrogen, boring operations were continued to 520 feet, when the lowering of the casing shut off the supply of water. A further bore was then put down at some distance from the first, and this, at a depth of 238 feet, yielded a fresh and clear water supply of about 145,000 gallons per day. Corrosion troubles occurred here also, and at the end of 1912 another bore was put down to a depth of 235 feet, artesian flows being struck at 187 feet and 235 feet. Towards the end of 1915 a flow of 200,000 gallons per day was struck at a depth of 125 feet on the Powerscourt Estate, near Maffra. Other bores are being put down in the locality.

Largely due to the failure of surface supplies in the drought of 1878 to 1886, no less than 499 bores were, before the end of 1888, put down by shire councils aided by the Government. The total depth bored was 40,000 feet; fresh water was struck in 78 instances; 47 yielded brackish but usable water; 229 were salt, while the balance were dry. The bores covered practically the whole of the settled portions of Northern and North-western Victoria and parts of Gippsland.

In the late eighties a number of bores were put down in the north-western part of the State, varying from 200 to over 2,000 feet in depth, but without any notable success. In 1897 a Board reported on boring for artesian water supply in the Mallee country, but this report was adverse, except as regards the extreme northern portion thereof. In 1906 eight bores were put down on the Overnewton Estate, Maribyrnong, to depths varying from 147 to 272 feet; small supplies of good and medium water for stock purposes were obtained, but only one of the wells yielded water fit for domestic purposes. In 1908 boring was commenced in the Mallee country near the border east of Pinnaroo in South Australia, and a line of bores from the Border to Kow Plains has proved the existence of a large sheet of underground water. Altogether, 94 bores have been successful in striking fresh water, and their depths vary from 155 to 752 feet, the water rising to within from 207 to 6 feet of the surface. In three instances the bores flow, the water rising from 4 to 17 feet above the surface. The fresh water extends nearly as far east as the 142nd meridian, and its northern limit is approximately the 35th parallel.

At the 30th June, 1923, the number of existing bores in use in the north-western portion of Victoria was 326, from which supplies are obtained by pumping. The total depth bored amounted to 90,600 feet, while the maximum and minimum depths at which water was struck were 700 and 150 feet respectively. The figures include also about 232 existing private bores, with a total depth of about 47,000 feet.

(iv) *Queensland.* A return relating to the 30th June, 1922, classifies the Queensland artesian bores under the following headings :—

ARTESIAN BORES.—QUEENSLAND, 30th JUNE, 1922.

Sunk by—	Artesian Flows.	Sub- Artesian or Pumped Supplies.	In Progress, Abandoned, or Uncertain.	Total.
Government	68	86	145	299
Local governing authorities	16	22	23	61
Private owners	1,182	1,455	961	3,598
Total	1,266	1,563	1,129	3,958

The estimated yield of water from 1,266 flowing bores on 30th June, 1922, was 393,073,360 gallons per diem. The deepest well was about 40 miles west of Blackall, lying east of the Barcoo River; this had a depth of 7,009 feet, and was stated to yield 70,000 gallons daily. Further sinking is in progress. The flow is, of course, a comparatively small

one, many wells yielding, when uncontrolled, from one to three million gallons a day. The waters of many of the wells have been analyzed, and some found suitable for wool-scouring only, others are suitable for watering stock but not for irrigation, owing to the presence of alkali; others again serve for both stock and irrigation, while some, such as those containing sulphuretted hydrogen, are not of any use. Water fit for stock may generally be said to be "safe" for domestic purposes in spite of its slightly mineral taste. The wells yielding the mineral waters known as "Helidon Spa," "Boonah Spa," and "Junot Spa," which are much in use in Queensland and New South Wales, are shallow wells from 60 to 200 feet in depth.

Of the 3,958 bores in Queensland, 360 have been put down by the State Government or Local Authorities, while 3,598 have been sunk by private enterprise; 1,266 bores are flowing, and 1,563 give a pumping supply, the balance of 1,129 are either in progress of construction, or are abandoned, or uncertain. The total depth bored is 3,521,978 feet. The minimum and maximum depths at which artesian water was struck are 10 feet and 6,000 feet respectively, while the temperature of the flow ranged from 81 to 210 degrees Fahr.

(v) *South Australia.*—(a) *General.* There were in South Australia 146 Government bores existing at 30th June, 1922, of which 37 were artesian and 109 sub-artesian. Of these, 107 were under 1,000 feet in depth; 24 from 1,000 to 2,000 feet; 7 from 2,000 to 3,000 feet; 5 from 3,000 to 4,000 feet; and 3 over 4,000 feet. The deepest flowing bore was at Patchawarra, on the Farina to Haddon, via Innamincka route, measuring 5,458 feet, but now yielding only 50 gallons per day. The maximum flow, viz., 1,250,000 gallons, is obtained at Coonie Creek, east of Lake Frome.

The following table gives particulars as to South Australian bores at 30th June, 1922 :—

EXISTING ARTESIAN BORES.—SOUTH AUSTRALIA, 1922.

Particulars.						Artesian and Sub-artesian.
Bores existing .. .. .	..	..	..	..	..	146
Total depth bored .. .. .	..	..	..	..	..	114,625
Daily flow .. .. .	..	..	..	..	gallons	(a) 13,204
Depth at which water was struck—						
Maximum .. .. .	..	..	..	..	feet	4,850
Minimum .. .. .	..	..	..	..	feet	55
Temperature of flow—						
Maximum .. .. .	..	..	..	..	°Fahr.	208
Minimum .. .. .	..	..	..	..	°Fahr.	82
Total cost of construction of bores up to 30th June, 1922 .. .. .	..	..	..	..	..	£326,611
Expenditure during year on boring operations .. .. .	..	..	..	..	..	(b) £565

(a) Flowing bores only. (b) £770 was received for casing from an abandoned bore, making a credit of £205 on the year's operations.

Of the above-mentioned bores, 47 are situated within the Great Artesian Basin, and the remainder are in the Lower Murray and other local basins.

(b) *Bores between the Murray and the Eastern Boundary of the State.* The sinking of bores across the Ninety-mile Desert between the Murray and the Victorian boundary was commenced in 1886 at Coonalpyn; with the exception, however, of salt water at 55 feet, no success was met with. Ki Ki bore was sunk in 1887, and at 361 feet a good supply of water fit for stock was struck. Tintinarra bore was sunk in 1887; it was artesian when first tapped. The water was found to be fit for locomotive engines and is still used for that purpose. The bore at Emu Flat was also sunk in 1887. In 1904 a bore was sunk at Cotton, and numerous successful bores have since been put down by the Public Works Department, and subsequently by residents of the district. The water rises to a distance from the surface of from 15 to 320 feet, and the maximum quantity obtained per diem is 48,000 gallons at the Gosden bore. Several wells, ranging

in depth from 55 to 221 feet, have also been sunk in this district. The latest Government bores are Kumara in the Hundred of Kingsford, and Perponda in the Hundred of Vincent. The former has a depth of 240 feet, and the water, which is in large supply, rises to within about 96 feet of the surface. The latter is 300 feet in depth, and the water rises to within 56 feet of the surface. The water is fresh, containing about $\frac{3}{4}$ oz. salts and other solid matter per gallon.

(c) *Bores West of Oodnadatta.* A series of bores has been sunk, beginning with Breaden bore, 20 miles west of Oodnadatta, which was put down in 1911. The others since put down in this district are at Gypsum, Imbitcha, Mirackina, Raspberry Creek, Appreentina, Wintinna, and Marla. Of these, the only artesian supply is at Raspberry Creek, where 1,000,000 gallons per day of good water are obtained. The depths of these bores range from 280 feet at Mirackina to 1,122 feet at Breaden, and the water from all of them is good. A bore now in progress about 70 miles west of Oodnadatta is expected to obtain an artesian supply at about 600 feet.

(d) *Other New Bores.* The Moutecollina Bore, on the Innamincka Track, has been completed, being sunk to a depth of 2,550 feet, and a splendid supply of good artesian water was struck at 2,450 feet. No. 2 bore, in the Stuart's Range Opal Fields, was sunk to a depth of 1,000 feet, and a useful supply of sub-artesian water obtained. Good water has also been struck in the latest bore completed, viz., Glenmanyie, east of Lake Frome, which is situated on the extreme southern edge of the Great Australian Basin.

(e) *Eyre Peninsula.* From time to time bores have been sunk on Eyre Peninsula but with little success. In some instances, stock water ($1\frac{1}{2}$ ozs. salts to the gallon) was obtained, but this only occurred on the Nullarbor plains. In all other cases the water struck was too salt to be used. Consequently the supply of water is now principally from catchments, and a number of reservoirs have been constructed to hold from 1,000,000 to 9,000,000 gallons each, while many underground tanks have been built to contain from 40,000 up to 500,000 gallons each.

(vi) *Western Australia.*—(a) *General.* The work by which the Government of Western Australia provides a permanent supply of water to Kalgoorlie, Boulder, and adjacent districts on the eastern goldfields comes properly under the heading of "Water Supply Works." A description of this undertaking is fully given in previous issues of the Year Book. (See No. 6, p. 576.)

The statistics in connexion with the Goldfields Water Supply undertaking and the Mines Water Supplies will be found in the chapter of this book dealing with *Local Government*.

The following table gives particulars regarding Western Australian artesian bores at 30th June, 1922 :—

EXISTING ARTESIAN BORES.—WESTERN AUSTRALIA, 30th JUNE, 1922.

Particulars.				State.	Private.	Total.
Bores existing	..	..	..	95	87	182
Total depth	..	..	.. feet	92,138	72,846	164,984
Daily flow	..	..	.. gallons	25,480,300	30,725,500	56,205,800
Depth at which artesian water was struck—						
Maximum	..	..	.. feet	2,275	(a)	..
Minimum	..	..	.. feet	39	(a)	..
Temperature of flow—						
Maximum	..	..	.. °Fahr.	140	(a)	..
Minimum	..	..	.. °Fahr.	75	(a)	..

(a) Not available.

To 30th June, 1922, the total number of Government bores was 95, while there were, in addition, approximately 87 private bores recorded.

(b) *The Coastal Plain Basin or Perth Area*, which, generally speaking, extends from Cape Leeuwin to Dongarra, and from which the Metropolitan Water Supply is largely drawn, yields a supply of water mostly fresh and suitable for domestic purposes, though towards the north it becomes brackish and is only suitable for stock.

There are 40 bores in the Metropolitan area, several of which have been put down to augment the hills supply and the domestic supply of the suburbs, and Fremantle is largely dependent upon this source.

(c) *The North-west Basin or Carnarvon Area* may be said to extend from Gantheaume Bay in the south to Onslow in the north, and embraces a very large tract of ideal sheep country.

Many private bores have been put down on sites which permit of the gravitation of the water for miles, and, by this means, a very considerable area has been made available for stock-raising. Some remarkable flows have been obtained and, in one case, at a depth of 300 feet a flow reputed to be 3,000,000 gallons per day was struck, the water being suitable for stock. In all, about 69 bores have been put down.

(d) *The Gulf Basin or Broome Area*. So far very little development work has been done. Artesian bores have been put down in the town site, and the domestic requirements of the town are entirely supplied from this source. The area extends from Condon in the south-west to the Meda River beyond Derby in the north, and for a considerable distance inland. So far only 7 bores have been sunk, 3 being at Broome, 2 at Derby, and 2 on the telegraph line on the road between Derby and Hall's Creek, about 67 and 80 miles inland.

(e) *Eucla Area*. This area extends from Eucla, on the South Australian border, to west of Israelite Bay. So far, beyond the bores put down on the route of the Trans-Australian Railway, very little has been done in proving the resources of this area. In 1902 the first bore was sunk, about 35 miles north of Madura, and sub-artesian water was struck at 430 feet, at an elevation of 400 feet above sea level. Following upon this, a deep bore was put down at Madura, below the cliff and nearer the coast, when an artesian supply of stock water was obtained at a depth of 2,041 feet, yielding 5,700 gallons per day. Later, about 20 bores were sunk along the survey line of the railway, which runs east and west about 90 miles inland. These bores were put in at intervals between the 205 mile peg and the South Australian border, and ranged in depth between 323 and 1,344 feet. In most instances only stock water was struck at depths varying between 300 and 1,300 feet, and the largest supply was estimated at about 10,000 gallons per day.

(vii) *Northern Territory*. In the Northern Territory, bores to the number of 159 were put down up to 30th June, 1921, 51 belonging to the Commonwealth Government. This number does not include bores put down by hand-boring plants for test purposes. One bore is artesian, and 158 give a pumping supply. The cost of construction and equipment of the Government bores exceeded £20,000. The total depth bored in State and private bores was 47,158 feet. Maximum depths were 1,474 feet in State, and 1,760 feet in private bores, and minimum depths were 110 feet and 60 feet respectively. Information relating to water boring was not collected in 1921-22.

§ 2. Irrigation.

1. *General*.—Australia's first experiments in irrigation were made with the object of bringing under cultivation areas in which an inadequate rainfall rendered agricultural and even pastoral occupations precarious and intermittent, and, although these original settlements have generally proved fairly successful, most of the States, instead of promoting new settlement in unoccupied regions, are adopting the policy of making existing settlement closer, by repurchasing large estates, subdividing them into holdings of suitable sizes for cultivation, and selling the land upon easy terms of payment. It is in connexion with this Closer Settlement policy that the special value of irrigation is recognized.

2. *New South Wales.*—(i) *General.* The recognition of the fact that the area suitable for cultivation might be extended largely by a system of water conservation and irrigation has induced the Government to undertake various detached works and schemes, which will constitute portion of the irrigation system necessary to serve the whole State.

The system, and the works necessary to its maintenance and development within the State of New South Wales, are under the control of the Water Conservation and Irrigation Commission, which consists of the Minister for Agriculture for the time being as Chairman, and two other Commissioners. The works controlled by the Commission include the great Murrumbidgee Irrigation Scheme, the small irrigation settlements at Hay and Wentworth, natural works of water conservation, shallow boring for settlers, and water trusts and artesian bore trusts operating under the Water Act. The Commission has control also of storages and diversions of water by private persons for purposes of conservation and irrigation.

(ii) *Murrumbidgee Irrigation Scheme.* The main features of the scheme include a storage dam across the Murrumbidgee to retain the floodwaters, which will be released for use lower down the river during the dry summer months; a movable diversion weir, about 240 miles below the dam, to turn the required amount of water from the river into the main canal; a main canal, leaving the river near the weir; four main branch canals and a series of subsidiary canals and distributing channels through the area to be irrigated; bridges, checks, regulators and other structures throughout the entire system, and meters for measuring the volume allowed to each farm. Towns and villages, roadways to serve each farm, and a general surface drainage system, are also included in this scheme.

Further details in respect of the storage dam, division weir and canals, together with the areas thrown open for settlement and the conditions of tenure, are contained in previous issues of the Year Book. (See Year Book No. 15, page 442.)

The irrigation area is situated on the northern side of the Murrumbidgee River where it is anticipated that there will ultimately be upwards of 200,000 acres under irrigation in blocks devoted to fruit and vegetable growing, dairying, stock-raising, etc. With the aid of irrigation the soil and climate of these areas are suitable for the production of apricots, peaches, nectarines, prunes, pears, plums, almonds, melons, cantaloups, and citrus fruits, also wine and table grapes, raisins, sultanas, figs, olives, and most varieties of vegetables and fodder crops. Dairying and pig-raising are being undertaken by large numbers of settlers in the areas, and the canning and drying of fruit and the production of wine are becoming industries of large dimensions. The district is already one of the greatest fresh fruit producing centres in the State.

An up-to-date butter factory, which is managed co-operatively by dairymen on the areas, is in operation at Leeton. The output for the year under review was approximately 365 tons, from 191 suppliers. The factory supplies ice to town residents and settlers. A fruit and vegetable canning factory has also been provided, which purchases vegetables and fruits grown by the settlers, and the output is rapidly increasing. Co-operative companies have been successfully floated for the handling of fruit not suitable for canning. Extensive dehydration works have been established, and successful pooling schemes evolved for the economic handling of fresh fruit. A bacon factory and abattoirs under the same management as the butter factory have been erected at Yanco, where the settlers' pigs are treated, and where stock for butchers is slaughtered for local consumption.

The State Nursery is one of the most important departmental undertakings on the irrigation areas. For some years past the Leeton Nursery has been supplying trees to settlers, and in 1916 a second nursery was established at Griffith. Every effort is made to supply the best trees, free from disease, and, so far as possible, use is being made of budding wood from proven trees in the Leeton Nursery and at the Yanco Experiment Farm.

The Department of Agriculture, which controls the Yanco Experiment Farm, has also established at Griffith (Mirrool irrigation area), a viticultural nursery for the propagation of vines on phylloxera resistant stocks. These stocks are intended not only for the supply of settlers on the areas, but for vignerons in all parts of the State.

An electric power station having been erected near Yanco Siding, electric light and power are supplied to the various factories, business people, and residents of Leeton, Griffith and Yanco, and the supply is also available for settlers when the number of applicants in any centre warrants the connexions being made.

On the 30th June, 1922, 1,781 farms were held, representing a total area of 108,240 acres, and the number of town blocks held was 721.

In the matter of cultivation, the following particulars indicate the extent of the work performed by the settlers:—There are approximately 7,023 acres under deciduous fruit, 3,921 under citrus fruits, and 4,797 under vines. The estimated population of the areas is about 10,000.

(iii) *Curlwaa Irrigation Area.* The Curlwaa irrigation area embraces 10,600 acres, of which on 30th June, 1922, irrigable holdings, comprising 1,813 acres, had been taken up, in areas of $1\frac{1}{2}$ to 40 acres. Of the balance, 7,718 acres were leased as non-irrigable holdings for short terms, while the remainder of the area is made up of roads, channel, and other reserves. Of the irrigable area, 1,000 acres are planted as orchards and vineyards, of which 750 acres are in full bearing. There is also a small area under lucerne. It has been proved that the Curlwaa soil is eminently suited to the growth of citrus and other kinds of fruit, and some of the finest oranges grown in New South Wales are produced on this area.

The estimated weight of dried fruits produced on the Curlwaa area in the year 1921–22 was 7,078 cwt., the principal yields being sultanas, 2,407 cwt.; peaches, 1,820 cwt.; and currants, 1,981 cwt. The value of the dried fruit production was estimated at £35,075, while fresh fruit, crops, and other produce of the value of £17,121 were also produced.

The pumping machinery consists of a suction-gas plant, one engine of 120 brake horse power driving one eighteen-inch centrifugal pump, and two engines each of 55 brake horse power driving a ten-inch centrifugal pump. The average combined capacity of the pumps is 10,600 gallons per minute. During the 1921–22 season, 190,194,000 cubic feet of water were supplied. The length of the main channels is about 10 miles. The land may be leased for periods not exceeding 30 years, the annual rent at present varying from 1s. to 35s. per acre. The rate for water is fixed from time to time by the Commission, and is at present, except in a few special cases, 20s. per acre per annum. In addition to the rental and water charges there is a general rate of 10s. per acre on the area in productive bearing. Each lessee is entitled to receive a quantity of water equivalent to a depth of 30 inches per annum.

In September, 1921, twenty-two irrigable blocks, comprising 450 acres, were set apart in a section of the area which had previously been leased as non-irrigable land. Half of these blocks were reserved exclusively for returned soldiers.

Satisfactory progress has been made in the development of an area set apart two years ago for settlement by returned soldiers. Other returned soldiers who acquired areas already partially developed are also making good progress.

(iv) *Hay Irrigation Area.* The Hay irrigation area consists of about 4,500 acres, of which on 30th June, 1922, the area held and used for irrigation purposes was 1,039 acres, in 109 blocks of from 3 to 34 acres. The term of lease is generally 30 years, and the annual rental from 5s. to 12s. per acre. In addition, there was at that date an area of 2,698 acres of non-irrigated land taken up in 48 blocks. The water rate is fixed from time to time, and during 1920–21 was £1 10s. per acre per annum. The pumping machinery is of similar type to that at Curlwaa, the capacity of the pumps being 4,000 gallons per minute. During the 1921–1922 season, 137,760,877 cubic feet of water were pumped with eight pumpings. Dairying is the principal industry, the cultivation of fruit being small.

(v) *Projected Irrigation Schemes.*—(a) *General.* The Water Conservation and Irrigation Commission is investigating schemes for utilizing the New South Wales share of the Murray waters, and for storing water for the purpose of irrigation and stock and domestic supply on the Lachlan, Macquarie, Hunter, Namoi and Peel Rivers.

(b) *Murray River.* The effect of constructing the Upper Murray storage will be to ensure at all times sufficient flow below Albury to permit of diversions for irrigation and stock and domestic supplies, and also to make good the losses in the river due to seepage, evaporation, and lockages. The Act provides that subject to certain conditions, New South Wales and Victoria shall share the regulated flow of the river at Albury, and shall each have the full use of all tributaries of the River Murray within its territory below Albury, with the right to divert, store, and use the flows thereof.

It is estimated that the New South Wales regulated river flow after the construction of the Upper Murray storage will amount to at least 120,000 acre feet per month at Albury during the irrigating season, and this will permit of a considerable amount of irrigation development along the river.

An investigation is being made into the manner in which the New South Wales proportion of the Murray waters can be most profitably applied, but as yet no conclusion has been reached.

(c) *Lachlan River.* The construction of a storage reservoir at Wyangala, below the confluence of the Abercrombie River, is being investigated with the intention of providing water in the river channel for pastoral purposes and for the irrigation of limited areas along the river banks. A proposal is also being investigated for the increase of the storage in Lake Cudgellico, which is fed from the Lachlan River, portion of the stored water being released in the summer months to supplement the flow of the river when necessary.

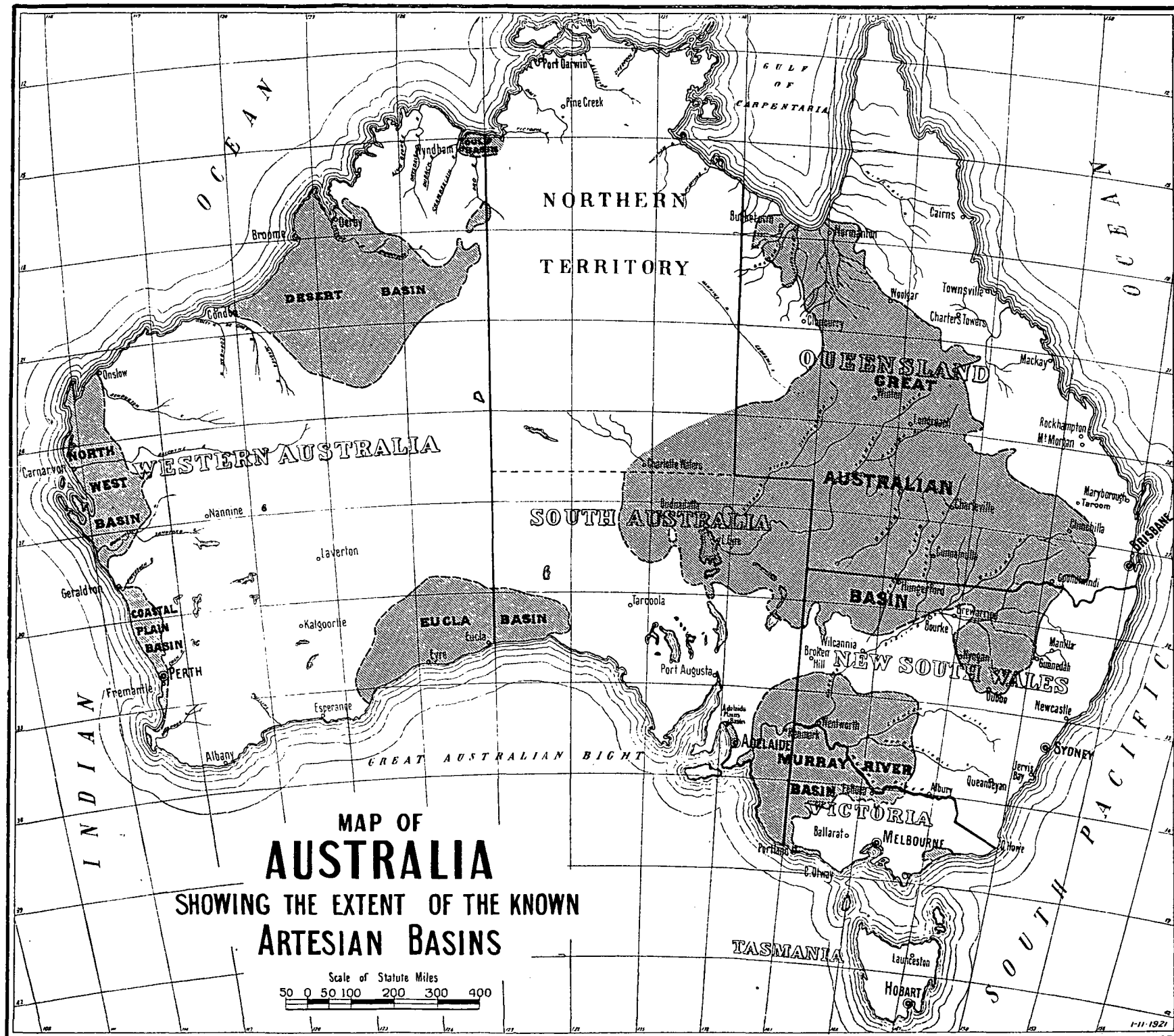
(d) *Macquarie River.* The construction of a storage reservoir on the river at Burrendong, below the confluence of the Cudgegong River, for the purpose of affording water for irrigation and stock and domestic supply below Wellington is now being investigated. Smaller schemes for the construction of storage dams at White Rock and on Campbell's River, at Bathurst, have also received consideration. Systematic gaugings are being made of the river flow with a view to determining the quantity of water which will be available if the storage dam be constructed.

(e) *Hunter, Namoi, and Peel Rivers.* Pumping by licensed private irrigators under the Water Act is increasing at such a rapid rate that in the case of some of the rivers, such as the Peel and the Hunter, it will not be possible to adequately supply the pumps in dry seasons until head storage works have been constructed. Investigations are in progress for storage dams on the Hunter and Peel Rivers, for dams on the Namoi River above Manilla, and lower down above the junction of the Peel River at alternate sites.

(vi) *Water Rights.* By Part II. of the Water Act 1912, the right to the use and flow and to the control of the water in all rivers and lakes which flow through, or past, or are situate within the land of two or more occupiers is vested in the Crown. Private rights are abolished, riparian law is simplified, and a system of licences is established for the protection of private works of water conservation, irrigation, water supply, drainage and the prevention of inundation of land. The enactment prevents litigation and determines the rights of riparian owners, and it also enables such owners to obtain licences to supply water to other occupiers of land not adjoining a river or lake.

During the year ending 30th June, 1922, 149 applications were received for fresh licences, comprising 90 in respect of pumps, or pumps in conjunction with dams or other works, 41 in regard to dams, and 18 other works. The number of applications received for the renewal of existing licences was 143; 91 of the applications were in respect of pumps, in some cases used in conjunction with dams or other works, 46 respecting dams, and 6 races and other works. Approximately, 1,481 licences were in force on the 30th June, 1921, and in the succeeding twelve months 160 new licences were issued and 68 were allowed to lapse, so that there were about 1,573 licences current on the 30th June, 1922.

(vii) *Water Trusts and Bore Trusts.* Part III. of the Water Act 1912 provides for the supply of water either for irrigation, stock, or domestic purposes, or for drainage. The liabilities thereon are repaid to the Crown, with interest spread over a period of years, and the works are administered by trustees appointed from among the beneficiaries under the Act, except in the case of trusts in the Western Division, where the Western Land Board is appointed as trustee. For the supply of water, trusts have been



This map was included in the Report of the Third Interstate Conference on Artesian Water held in Adelaide during September, 1921. It contains the latest available information regarding the extent of the artesian basins. See also letterpress on page 887.

constituted in connexion with (a) seventy-eight artesian wells; (b) nine schemes for the improvement of natural off-takes of effluent channels for the purpose of diverting supplies from the main rivers; (c) in three instances for the construction of weirs across stream channels; and (d) two pumping schemes, one from natural water-courses, and one from a well. The total area included within these trusts amounts to 7,637,967 acres.

3. Victoria.—(i) *General.* The Water Conservation Works in Victoria consist of irrigation works proper, and those providing mainly a domestic supply, such as the works for the supply of Melbourne, controlled by the Melbourne and Metropolitan Board of Works; the Coliban, Wonthaggi, Broken River, Kerang Lakes, Naval Base and Mornington Peninsula, and Mallee Supply Works administered by the State Rivers and Water Supply Commission; and other works of domestic supply controlled by Water Works Trusts or Municipal Corporations. Particulars of the works not controlled by the Commission will be found in the chapter on Local Government in this volume. With the exception of that of the First Mildura Irrigation and Water Supply Trust, all the irrigation schemes, and the more important domestic and stock water-supply works in rural districts, are vested in and controlled by the State Rivers and Water Supply Commission, a body composed of three members, which was created by the Water Act 1905, now incorporated in the Water Act 1915.

(ii) *Irrigation Schemes.* (a) *General.* This division comprises the schemes constructed and under construction for the supply of water to some twenty-four irrigation districts. Up to 1906 these schemes were controlled by local Trusts, which had obtained the moneys for their construction on loan from the State. By the Water Act 1905 all local control was abolished except in the case of Mildura, and the districts were transferred to the State Rivers and Water Supply Commission. Since that date the Government has adopted a vigorous irrigation policy, and the capital expenditure at 30th June, 1922, on water supply in the irrigation and water supply districts under the control of the Commission and at Mildura, exclusive of the amount (£443,000) expended by it on River Murray Agreement Works, was £5,684,000. The irrigation works draw their supplies mainly from headworks constructed on the Murray, Goulburn, and Loddon Rivers. The cost of these headworks which now stands at £1,124,000 is not debited to any particular districts but is borne by the State. The extent of land under irrigated culture last year for all kinds of crop was 288,000 acres. Although this is some 83,000 acres less than the record area irrigated in the year 1919–20, it is nearly 14,200 acres above the average of the previous five years.

(b) *Goulburn River Scheme.* The Goulburn River Gravitation Scheme (see Official Year Book No. 13, map on page 561) is the largest of Victoria's irrigation enterprises. It serves, either for irrigation or domestic and stock purposes, throughout an area of 870,000 acres of land in the valleys of the Goulburn, Campaspe and Loddon Rivers. The present headwork of the system is a diversion weir on the Goulburn River, near Nagambie. It is constructed of concrete masonry, with 21 flood gates, which raise the up-stream water-level 10 feet above the concrete crest. These gates are lowered during high stages of river-flow to provide a clear waterway for the discharge of floods. The weir has a total length, including channel regulators, of 925 feet, and a height of 50 feet. The water is diverted by two main channels, the eastern carrying 330 cubic feet per second (660 acre feet per day) a distance of 33 miles to the country north of the Broken River, while the western, which has a capacity of 1,700 cusecs,* and a length of 23 miles, is used to feed distributaries of the Rodney District, and to fill Waranga Reservoir, the present principal storage basin of the scheme. This reservoir, formed by an earthen embankment $4\frac{1}{2}$ miles long across a natural depression, covers an area of $22\frac{1}{2}$ square miles to an average depth of 23 feet, and stores 333,400 acre feet. Two main channels issue from this reservoir, the Waranga-Rodney, of 250 cusecs* capacity, which feeds Rodney distributary channels, and the Waranga-Campaspe-Loddon, which leaves the reservoir with a capacity of 1,000 cusecs, reducing to 200 cusecs at the Serpentine Creek—92 miles westward—the present termination. This main channel is being extended to the west bank of the Loddon, and the system otherwise improved with a view to providing an irrigation supply to lands hitherto dependent entirely on the Loddon River. The total length of distributary channels is 1,650 miles.

* Cusecs = Cubic feet per second.

In order to meet the increasing demand for water in dry seasons, and to provide an irrigation supply for other suitable lands, the Commission is constructing a storage reservoir on the Upper Goulburn, just below its junction with the Delatite River, at what is known as the Sugarloaf site. This reservoir will submerge an area of 7,600 acres, and store about 300,000 acre feet of water, bringing the total capacity of the Goulburn storages to 654,000 acre feet. The foundations of the Sugarloaf structure will permit of the dam being raised, if necessary, to a height of 190 feet above the river bed. This would add 8,600 acres to the area submerged, and would increase the storage capacity from 300,000 to 900,000 acre feet. The construction of the first stage of this reservoir is nearing completion, and the storing of water was commenced in 1922.

The portion of the State served by this system comprises 21,000 acres east of the Goulburn, 565,000 acres between the Goulburn and the Campaspe, and 284,000 acres between the Campaspe and the Loddon. These areas include the irrigated Closer Settlements at Shepparton, Stanhope, Tongala, Rochester, and Dingee, as well as the districts formerly controlled by the Rodney and Tragowel Plains Irrigation Trusts, where the holdings are larger than in Closer Settlement areas. The balance of the area, including Deakin district, is provided with a domestic and stock supply, and water is sold for occasional irrigation on application. The amount of the compulsory charge for irrigation water allotted as a "right" is at present 7s. per acre foot in the two districts—Tragowel Plains and Dingee—farthest removed from the sources of supply, and 6s. per acre foot elsewhere.

(c) *Loddon River Scheme.* This also is wholly a gravitation system, with a regulating weir on the Loddon at Laanecoorie as its headwork. Its storage capacity is 14,000 acre feet, and other works include timber diversion weirs at Serpentine and Kinypanial, and 160 miles of channels in the Boort district, which supply an area of 74,000 acres for domestic and stock purposes and partial irrigation.

(d) *Murray River Schemes.* These comprise both gravitation and pumping schemes. The only wholly gravitation system is that known as the Kow Swamp scheme, which supplies the Kerang irrigation district of some 85,000 acres.

(e) *The Cohuna, Gannawarra, Koondrook and Swan Hill Schemes* are combined gravitation and pumping schemes, the pumped supplies being supplemented at varying stages of river level by the gravitation water.

The area covered by these schemes comprises 151,000 acres, and the quantity of water allotted as a "right" is one acre foot per irrigable acre. The compulsory charge is at present 6s. per acre foot of such water right in Swan Hill district, and 7s. per acre foot in the other three districts. In Kerang district—not under a compulsory irrigation charge—water is sold to irrigators on application at a charge not exceeding 3s. per acre foot of water supplied. In the Swan Hill district 2,600 acres of irrigable land were specially purchased for soldier settlement, and subdivided into 83 holdings. The channel system has been correspondingly extended. There being still a steady demand for irrigable blocks in this district further purchases of land for subdivision are contemplated.

(f) *The Nyah Irrigation Area* is supplied with water diverted from the Murray by a high-lift pumping plant. The settlement contains 3,800 acres, subdivided into 208 holdings of an average area of 17 acres, of which 203 are settled. The settlers include 60 discharged soldiers. Water rights are apportioned to these holdings on the basis of $2\frac{1}{2}$ acre feet of water for each irrigable acre, and the compulsory charge is at present 20s. per acre foot of such water rights. The land is devoted mainly to vineyards and orchards, and the settlers, taken as a whole, are making good progress. The value of irrigation to the district is reflected in the selling price of the land, fully planted blocks bringing remarkably high prices.

(g) *The Merbein Irrigation Area* comprises 8,300 acres, originally Crown lands. This settlement now contains 384 holdings, averaging 21 acres each, all of which are settled, the settlers including 166 discharged soldiers. The water is pumped from the Murray, and the land settlement conditions, water rights apportioned, and the compulsory charge are the same as at Nyah.

(h) *The Red Cliffs Irrigation Settlement* comprises 15,000 acres of first-class irrigable land adjoining the Mildura Settlement. It is the irrigable portion of the large Red Cliffs estate of 33,000 acres, known as the Debenture Holders' Land, acquired by the State for soldier settlement. The scheme of works for this district includes a pumping plant which will have a capacity of 250 cusecs, or 500 acre feet per day—lifted 105 feet. One unit, a 36 inch high lift centrifugal pump (capacity 50 cusecs) has been installed, and the remainder of the plant—two 48 inch turbine pumps (capacity 100 cusecs each)—are under construction. Each pump will be driven by a 1,600 b.h.p. steam turbine. The rising main is of reinforced concrete, 6 feet 6 inches in diameter, length 34 chains. An electric generator, of about 350 k.w. capacity, will be installed to provide for relifts, to water those parts of the area above the general level.

(i) *Werribee River Schemes.* (i) *Bacchus Marsh.* The headwork of this gravitation scheme is a reservoir of 15,000 acre feet capacity on Pyke's Creek, a tributary of the Werribee, the intake from the creek catchment being supplemented by a tunnel through a dividing spur, which taps the Werribee River near Ballan. The area of the district is 6,700 acres—half of which is irrigable—and includes some of the richest lucerne land in the State. The annual water right is one acre foot per irrigable acre, and the present compulsory charge is 22s. 6d. per acre foot of such right. The higher portion of the district receives a supply for domestic and stock purposes.

(ii) *Werribee.* This is another gravitation scheme on the same river, with a reservoir at Melton as its headwork. The irrigation district comprises 10,000 acres of first-class land, being the irrigable portion of the Werribee Closer Settlement Estate, which is within 20 miles south-westerly of Melbourne. The water right allotment is one acre foot per irrigable acre, and the charge at present is 12s. per acre foot. The non-irrigable portion of the estate, containing about 13,000 acres, is supplied with water for domestic and stock purposes.

(j) *Macallister River (Maffra) Scheme.* The works of this scheme, now in course of construction, comprise a storage reservoir on the Macallister River, at Glenmaggie, near Heyfield, and a system of main and distributary channels capable of commanding, by gravitation, some 80,000 acres of the rich river flats along the Macallister, Avon, and Thomson Rivers, near Maffra, Stratford, and Sale. The design for the dam—a large cyclopean concrete structure—provides for the raising of water to a maximum height of 100 feet above the foundations. The capacity of the storage will be 150,000 acre feet, while the unregulated flow of the river will yield an additional 100,000 acre feet. The commanded lands are specially suitable for beet culture and dairying, and include some 4,000 acres acquired by the State Rivers and Water Supply Commission for soldier settlement. Outlets for the produce of irrigated farms are already provided by the sugar, butter, and condensed milk factories, which are within easy reach; while the proximity to railway stations ensures to settlers the necessary transport facilities.

(iii) *Domestic and Stock Schemes.* (a) *General.* The second division takes into account the schemes constructed and under construction for the supply of water for domestic and stock purposes, the capital expenditure on which at 30th June, 1922, was £5,778,000. The area of country lands artificially supplied with water for these purposes is nearly 21,000 square miles. The number of towns supplied, exclusive of the City of Melbourne and its suburbs, is 169, serving an estimated population of 333,600. In addition to the Commission's districts, some large areas are still administered by local authorities.

(b) *Wimmera-Mallee System.* The principal scheme in this division is that known as the Wimmera-Mallee Gravitation Channel System. This comprehensive scheme of works will compare favourably, it is believed, with any similar individual scheme for domestic and stock service, in any part of the world. The main supply is drawn from four reservoirs in the catchment area of the Wimmera River, at the foot of the Grampians Ranges, viz.:—Lake Lonsdale, Wartook, Fyans Lake, and Taylor's Lake. The reservoirs in use, including some minor works, have a combined storage capacity of 148,000 acre feet. The completion of the works in progress will bring this total to 200,000 acre feet. The water is conveyed, partly by natural water-courses, but chiefly

by artificial channels, aggregating over 4,500 miles in length, over farming districts comprising about 10,000 square miles, approximately one-ninth of the whole State (see Official Year Book No. 13, map on page 562).

(c) *Northern Mallee Water Supply Scheme.* In what is known as the northern Mallee, an area of about 1,250,000 acres, adjoining the Wimmera-Mallee Gravitation Channel System, but above its channel level, the Commission has provided a water supply for the large wheat holdings in the Walpeup district, by means of bores and large public tanks. The number of successful Government bores in use in this area is 92, their average depth being 420 feet. There are also 163 tanks, having a total capacity of 916,000 cubic yards, or 155 million gallons.

(d) *Naval Base and Mornington Peninsula Scheme.* Another scheme in this division which calls for mention here is the Naval Base and Mornington Peninsula Scheme. This comprehensive scheme—prepared at the request of the Naval Authorities—is for the supply of water to the Flinders Naval Base, and for the service of fifteen townships *en route*, including Berwick, Beaconsfield, Pakenham, Aspendale, Chelsea, Carrum, Frankston, Mornington, and Hastings. An ample supply of water is obtainable from the headwaters of the Bunyip River, which drains some 30 square miles of forest country above the point of off-take. The works are so far advanced that water is already being delivered at the Naval Base, and to the townships of Mornington, Frankston, Aspendale, and the intervening bay-side resorts, as well as the inland townships of Beaconsfield, Berwick, Cranbourne, Somerville, and Bittern.

The scheme is being extended to supplement the supply to the township of Dandenong, hitherto controlled by a local Trust, the works of which were recently transferred to the Commission, which will administer them as part of the general scheme.

(e) *Flood Protection.* The Water Acts of Victoria provide for the constitution of Flood Protection Districts, in which the residents are rated for schemes carried out for their benefit. The works are constructed, and districts administered by the State Rivers and Water Supply Commission, and the Commission is carrying out extensive schemes at Koo-wee-rup and Cardinia, in the south-eastern portion of the State, and works, on a smaller scale, at Echuca.

(iv) *Mildura.* The Mildura Irrigation Scheme is controlled by the First Mildura Irrigation Trust, and water is obtained by pumping from the River Murray. The area of the settlement is 45,000 acres, of which 13,000 acres are under intense culture, vines predominating. During the year ending 30th June, 1922, the Trust's receipts aggregated £55,127, and its expenditure £49,131, whilst loans—exclusive of £8,029, arrears of interest—advanced by the Government amounted at 30th June, 1922, to £95,709. The number of water acres supplied during the year was 44,150.

4. *Queensland.*—The main irrigation works in Queensland are as follows:—(a) those at Ayr, which utilize the waters of the Burdekin River, and shallow wells on its banks; (b) Townsville (wells, creek, and river); (c) Rockhampton (wells, river, creek, etc.); (d) those at Bingera, near Bundaberg, which utilize water pumped from the Burnett River just above the point of meeting of the salt and fresh waters, and (e) those at Fairymead, which utilize water pumped from a number of shallow spear wells sunk on the alluvial flats on the north side of the Burnett River and about 6 miles from Bundaberg. There were 754 irrigators in the State in 1921, chiefly farmers and graziers, and the area irrigated was 11,264 acres.

5. *South Australia.*—(i) *The Renmark Irrigation Trust.* The Renmark Irrigation Trust was established on similar lines to Mildura, but on a smaller scale. The area of settlement is 30,000 acres, and the irrigated area 7,600 acres. The population of the town and settlement is 4,800. Sultanias, currants, doradillos, gordos, oranges, apricots, peaches, pears, prunes, olive oil, and grape spirit are the chief products. There are two distilleries for the manufacture of grape spirit and several packing sheds for dried fruits. The dried fruit pack for 1922 amounted to 2,743 tons.

(ii) *Other Waterworks.* A number of country water works are under the control of the Public Works Department. As, however, they are not irrigation works properly

so called, but are used for supplying water for domestic purposes, etc., to several towns, no further reference will be made to them in this chapter. (See the chapter on Local Government.)

(iii) *Areas under Irrigation.* The Irrigation Areas on the River Murray above Morgan under Government control, up to the end of February, 1923, contained 16,293 acres of irrigable land, allotted to 942 settlers, including 539 returned-soldiers, about 1,280 acres reserved by the Department for fodder cultivation, etc., 6,600 acres ready for allotment, about 5,600 acres in course of preparation, and 24,200 acres under survey. The pumping plants at present installed on these areas aggregate 6,233 brake horsepower, with a pumping capacity of 7 million gallons per hour.

The *Cadell Irrigation Area* is 7 miles by river above Morgan. The total area of settlement is 2,726 acres, of which 1,183 are irrigable. Blocks have been allotted to 78 soldier settlers, and the balance is ready for allotment in 7 blocks. The area is suitable for fruit growing.

The *Waikerie Irrigation Area* is 39 miles above Morgan by river. This area includes the old Waikerie and Ramco settlements. The total area of settlement is 9,276 acres, of which 2,806 acres is first-class irrigable land, growing fruit trees and vines. The irrigable area has recently been extended to 3,366 acres. The area allotted is divided between 136 settlers, and a further 26 could be accommodated.

The *Holder Irrigation Area* adjoins the Waikerie Irrigation Area, and has been incorporated as a portion of that area. It contains 471 acres of irrigable land, and 1,890 acres of dry land. Blocks have been allotted to 23 settlers, including 10 soldier settlers, and a further 3 settlers can be accommodated.

The *Kingston Irrigation Area* is situated 75 miles above Morgan by river, and comprises the old village settlement of that name. It has a total area of 3,748 acres, of which 493 acres are irrigable. This area was allotted to 30 settlers in July, 1914, and is used for fruit and vine culture.

The *Moorook Irrigation Area*, adjoining the Kingston Area, contains 5,960 acres of land, of which 1,062 acres is good land suitable for vines and fruit culture. Altogether 1,041 acres of irrigable land have been allotted to 55 settlers, of whom 34 are soldier settlers.

The *Cobdogla Irrigation Area* is on the opposite side of the river to Kingston and Moorook Areas, and comprises 136,600 acres. This area contains about 30,000 acres of first-class land, capable of intense culture. The area is divided into five divisions, the Cobdogla, Nookamka, Loveday, Weigall, and MacIntosh divisions. The total area of irrigable land contained in these divisions is about 30,470 acres, of which 661 acres have been allotted to 20 settlers in the Cobdogla division, and 1,790 acres to 116 soldier settlers in the Nookamka division. Constructional work on the Loveday division will shortly be completed, and the remaining divisions are under survey, and construction work will shortly be undertaken there. Pumping plants have been installed on the Cobdogla, Nookamka, and Loveday divisions, with a total capacity of 35,700 gallons per minute, while the contemplated erection of additional plant capable of pumping 80,600 gallons per minute will bring the pumping capacity of these three divisions to 116,300 gallons per minute.

The *Berri Irrigation Area* is 120 miles above Morgan by river, and contains a total area of 23,400 acres, of which 8,100 acres is first-class land for fruit and vine culture. A total of 7,461 acres of irrigable land has been allotted to 458 settlers, of whom 275 are soldier settlers, and 489 acres are ready for allotment in 33 blocks. The pumping plant has a capacity of 33,700 gallons per minute against total heads varying from 50 feet to 120 feet.

The *Chaffey Irrigation Area* comprises a large area of country adjacent to Renmark, at present known as Ral Ral. Survey work is proceeding over 14,000 acres of prospective irrigable land. A portion of this area, 1,760 acres, has been subdivided into 110 blocks, and is now ready for allotment to soldier settlers. A pumping plant with a capacity of 12,500 gallons per minute against a total head of 50 feet has been installed. The balance of the area under survey at present, viz., 12,200 acres, will be irrigated with a lift of

100 feet, and the preliminary survey work is being carried out as rapidly as possible. The future extension of this area may reach a total of 100,000 acres of irrigable land, with lifts not exceeding 100 feet.

The *Irrigation and Reclaimed Swamp Areas* under Government control on the River Murray below Morgan contain 6,100 acres of high, irrigable, and reclaimed swamp land, allotted to 250 settlers, of whom 64 are discharged soldiers. The former land is irrigable by pumping, and the latter by gravitation. There are also 1,500 acres ready for allotment to 70 settlers, and 5,700 acres under preparation, which will accommodate 260 additional soldier settlers. Pumping plants installed total 1,500 b.h.p., with a capacity of 3½ million gallons per hour.

Mobilong and Burdett Areas adjoin Murray Bridge, and contain 575 acres of reclaimed fodder land with 45 settlers.

Long Flat and Monteith Flat below Murray Bridge have between them a reclaimed area of 1,342 acres, divided between 57 settlers.

Swanport Area below Murray Bridge has 191 acres of fruit and fodder land, and has 7 soldier settlers.

The *Jervois Irrigation Area* is in course of construction. It is 15 miles below Murray Bridge, and includes 1,224 acres of irrigable and reclaimed land, which will accommodate 62 settlers when completed.

The *Woods Point Area* is 12 miles below Murray Bridge, and contains in its total area of 3,726 acres about 1,296 acres of reclaimed land. The area is in course of preparation, and will accommodate 52 soldier settlers.

The *Wellington Area* is 18 miles below Murray Bridge, and has an area of over 12,000 acres; of this area about 1,820 acres are reclaimed land. This area will provide for 80 soldier settlers, and is at present in course of preparation for settlement.

The *Mypolonga Area* is 9 miles above Murray Bridge. This area has a river frontage of 7 miles. The total area of this settlement is 5,800 acres, of which 1,036 are irrigable and 1,627 acres reclaimed land. The area has 84 settlers.

The *Pompoota Area* is situated 13 miles above Murray Bridge, and was previously used as a Training Farm for prospective soldier settlers. The area contains 4,127 acres, of which 670 acres are fruit and fodder land. Blocks have been allotted to 26 soldier settlers, and a further 5 settlers can be accommodated.

The *Wall Area*, 16 miles above Murray Bridge, has 768 acres of irrigable and reclaimed land. Twenty soldier settlers are settled on the area, and blocks are available for 9 more.

The *Neeta and Cowirra Irrigation Areas* are 20 miles above Murray Bridge, and include 410 acres of highly irrigable land, and 1,745 acres of reclaimed fodder land. These areas are in course of preparation, and at present 20 soldier settlers have been placed on the blocks. A further 80 settlers can be accommodated when areas are complete.

The *Baseby Area* is about 21 miles above Murray Bridge, and has an area of 1,350 acres, of which 528 acres will be reclaimed and allotted to 26 soldier settlers. Development work is proceeding on this area.

Lake Albert. There is a possibility of this lake being reclaimed in the near future, which will give an area of about 40,000 acres suitable for dairying.

The total area, including aforementioned areas adjacent to the River Murray possible of reclamation or of being brought under irrigation, is 250,000 acres. The reclaimed lands consist of peaty soils composed of rich river silt, and are suitable for the growth of lucerne and other fodders, onions, potatoes, etc. The soils of the irrigable lands have already proved their suitability for the production of peaches, apricots, nectarines, oranges, lemons, figs, and grapes.

(iv) *Allotment of Irrigated Land.* The allotment of irrigated land and the terms of settlement, as well as the charges for water and assistance rendered to the settlers by the Irrigation Department, are referred to at length in previous issues of the Year Book (see Year Book No. 15, page 453). All lands are allotted under perpetual lease in blocks up to 50 acres of irrigable or reclaimed land. In addition, areas of non-irrigable land are allotted to lessees of irrigation and reclaimed blocks for dry farming.

On the irrigable land, the water rate has been fixed at 60s. per acre per annum for the first four years, after which an amount will be charged sufficient to cover actual cost of supplying water, and interest on pumping plant, channels, etc., whilst on the reclaimed lands an amount is charged to meet the annual management, drainage and maintenance expenses. On the irrigable lands, each lessee is entitled for the water rate to 24 acre inches per annum, supplied in four irrigations; special irrigations and domestic supplies are supplied at times other than during the general irrigations, at a nominal cost. On the reclaimed lands water is supplied regularly by reticulation from the river.

At the present time no land is available for civilian settlers, and it will possibly be two years before soldiers' demands are satisfied. So far as soldiers are concerned, the Department, in most instances, prepares and plants the land for fruit culture prior to allotment, and clears, channels, grades, and plants up to 10 acres of vines.

6. *Western Australia.*—In this State an Irrigation Act provides for the constitution of irrigation districts. At Harvey, works for irrigating about 4,000 acres devoted to fruit growing, principally oranges, were opened on the 21st June, 1916. A scheme is now in preparation for irrigating a further area in the same district.

Numerous small private irrigation schemes are in full operation on many of the south-west rivers, in connexion with fruit, fodder, and potato growing.

7. *Murray Waters.*—(i) *General.* The relative rights of the States of New South Wales, Victoria, and South Australia to the waters of the Murray River being undetermined, negotiations which had been in progress for some considerable time resulted in the passing of the River Murray Waters Act 1915. This Act ratified and approved certain resolutions which had been agreed to by the Prime Minister of the Commonwealth and the Premiers of New South Wales, Victoria, and South Australia at the Premiers' Conference held at Melbourne in April, 1914. (See Official Year Book, No. 8, page 507.)

(ii) *Amendment of the Agreement.* As a result of proposals placed before the Conferences of Premiers which met on 25th May and 20th July, 1920, and the discussions which took place thereon, an agreement, providing for the amendment of the River Murray Agreement of 1914, was entered into by the four Contracting Governments on 23rd November, 1920. In the Agreement as so amended it was proposed that the construction of all works covered by the River Murray Scheme should be placed under the control of the River Murray Commission in lieu of the three Constructing Authorities as provided for in the Agreement of 1914. It was also provided that the four Contracting Governments should contribute towards the cost of the scheme in equal shares, and that all plant required for the construction of works should be purchased by the Commission from funds provided by the four Contracting Governments. The Parliaments of the Commonwealth and the States of New South Wales, Victoria, and South Australia have passed legislation giving effect to the amendments proposed.

(iii) *Constitution of River Murray Commission.* The River Murray Agreement was signed on 9th September, 1914, and in November, 1915, Acts ratifying the Agreement were passed simultaneously by the Parliaments of the Commonwealth and the three Contracting States. On 31st January, 1917, the Agreement was brought into operation and the River Murray Commission, consisting of a representative of each of the four Contracting Governments, was appointed.

The Commission is charged with the duty of giving effect to the Agreement and the River Murray Waters Acts.

(iv) *Activities.* The Agreement provides for the construction of the following works :—

To be constructed by the Constructing Authorities for New South Wales and Victoria severally or jointly as may be agreed upon.—The Hume Reservoir; seventeen Weirs and Locks on the River Murray between Echuca and Wentworth.

To be constructed by the Constructing Authority for New South Wales.—Nine Weirs and Locks on the River Murrumbidgee.

To be constructed by the Constructing Authority for South Australia.—The Lake Victoria Storage; nine Weirs and Locks on the River Murray below Wentworth.

The following works are now in course of construction, in accordance with the designs and estimates approved by the Commission :—

The Hume Reservoir—estimated cost £1,639,000. This Reservoir, which will be created by the construction of a dam immediately below the junction of the Mitta Mitta and Murray Rivers, will have a storage capacity of 1,000,000 acre feet. Work is proceeding on both the New South Wales and Victorian sides of the River, the total expenditure as at the 31st March, 1923, being £670,000.

Weir and Lock at Torrumbarry, near Echuca.—Estimated cost £120,000 (subject to revision). This Weir and Lock, which is now approaching completion, will allow of the diversion of water for irrigation purposes over considerable areas on both sides of the river.

The Lake Victoria Storage—Estimated cost £320,000. The scheme approved provides for the construction of embankments and channels, and the improvement of Frenchman's Creek (the inlet channel to the Lake) and the Rufus River (the outlet channel). The Lake, on completion of the works proposed, will have a storage capacity of 514,000 acre feet. Work on this storage, which has been greatly delayed on account of industrial disputes, is now well advanced.

Weir and Lock No. 9, situated immediately below the junction of the Frenchman's Creek (the inlet channel to the Lake Victoria Storage) and the main stream. Estimated cost £186,898.

Weir and Lock No. 5, near Renmark—Estimated cost £275,000.

Weir and Lock No. 3, near Kingston—Estimated cost £126,328.

The Weir and Lock at Blanchetown (No. 1), which was commenced by the South Australian Government before the River Murray Agreement came into effect, was completed, with the exception of minor details, during the early part of 1922, and has been brought into operation. The expenditure incurred on this work amounted to approximately £230,000. All vessels carrying goods passing through the lock will be liable to the payment of tolls at the rate of 6d. per ton of freight carried, in accordance with the Tolls Regulations prescribed by the Commission, in pursuance of Section 7 of the River Murray Waters Act 1915, and appearing in the *Commonwealth Gazette* of 23rd March, 1922.

(v) *Size of Locks.* It has been decided by the Commission and the Contracting Governments that all locks in the River Murray below the junction of that River with the River Darling shall be constructed of a length of 275 feet, and that the length of the locks to be constructed in the Murray above that point and in the River Murrumbidgee shall be 170 feet. It was recognized that the heavier traffic on the River Murray below its junction with the River Darling necessitated the construction of locks of a greater length than was required in connexion with the upstream locks.

(vi) *Finance.* The estimated cost of the whole of the works covered by the River Murray Scheme is set down in the Agreement at £4,663,000, and it is provided that the four Contracting Governments shall contribute thereto in the following proportions :—Commonwealth, £1,000,000; New South Wales, Victoria, and South Australia, each £1,221,000. It is now clear that, owing mainly to the increases which have occurred in the costs of materials and labour since the original estimate was framed, the ultimate expenditure on these works will be considerably in excess of that estimate. The actual expenditure incurred to the end of March, 1923, on the works carried out by the three Constructing Authorities amounted to £1,850,000, towards which the Commonwealth Government contributed £405,000, the balance having been borne by the three Contracting States in equal proportions.

(vii) *Estimated Expenditure during Year 1923-24.* The estimated expenditure during the financial year 1923-24 prepared by the Commission and forwarded to the four Contracting Governments in accordance with the requirements of Clause 34 of the Agreement, is £1,039,000, made up as follows :—

New South Wales—Hume Reservoir, £265,000 ; Weir and Lock, Wentworth, £80,000 ; Surveys and Borings, £20,000 ; total, £365,000.

Victoria—Hume Reservoir, £260,000 ; Weir and Lock, Torrumbarry—completion surveys and general, £10,000 ; Weir and Lock, Mildura, £30,000 ; total, £300,000.

South Australia—Weir and Lock No. 2, £30,000 ; Weir and Lock No. 3, £64,000 ; Weir and Lock No. 5, £80,000 ; Weir and Lock No. 9, £120,000 ; Lake Victoria Storage, £80,000 ; total, £374,000.

The four Contracting Governments will contribute towards this proposed expenditure in the following proportions :—Commonwealth, £222,813 11s. ; New South Wales, £272,062 3s. ; Victoria, £272,062 3s. ; South Australia, £272,062 3s.

(viii) *Gaugings.* All gaugings on the River Murray and its tributaries are made by the three Contracting States, which, in pursuance of an arrangement arrived at with the River Murray Commission, furnish that body periodically, for purposes of the Agreement, with the results of such gaugings. Arrangements were made, as a result of recommendations by a Conference of Gauging Officers convened by the Commission, for the adoption of uniform methods in connexion with the recording of gaugings by the three State Authorities, and the returns furnished to the Commission setting out the results of such gaugings. The returns furnished to the Commission during the year 1921-22 indicated that the total flow of the River Murray at Renmark during that year was 14,180,792 acre feet, while the total volume of water diverted by artificial or partly artificial means was estimated at 1,466,339 acre feet.