SECTION XIV.

WATER CONSERVATION AND IRRIGATION.

§ 1. Water Supply Works.

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 the Commonwealth 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 section dealing with "Local Government."

2. **The Goldfields Water Supply of Western Australia.**—The scheme by which the Government of Western Australia undertook to provide a permanent supply of water for the population on the eastern goldfields of that State comes properly under the heading of "Water Supply Works."

The Act under which the works were constructed was introduced in Parliament by Sir John Forrest, G.C.M.G., then Premier of Western Australia, in September, 1896, and provided for an expenditure of £2,500,000 and a daily supply of 5,000,000 gallons. The works, designed by the late Mr. C. Y. O'Connor, Engineer-in-Chief of the State, were originally known as the "Coolgardie Water Scheme," but are now officially called the "Goldfields Water Supply." The first construction work in connection with the scheme was commenced early in 1898, and the water was delivered in Kalgoorlie in January, 1903. The source of supply is the Helena River, in the Darling Ranges, where, at about 18 miles from Perth, an impounding reservoir, 760 acres in extent, with a catchment area of 569 square miles, has been constructed. From the impounding reservoir the water is pumped through a steel main of the locking-bar type, 30 inches in internal diameter, by a series of eight pumping stations located at intervals along the main. Each pumping station, except No. 1, which draws direct from the reservoir, is provided with a suction tank which receives the water pumped by the preceding station. The last pumping station delivers the water into a main service reservoir of 12 million gallons capacity, situated at Bulla Bulling at a height of 1290 feet above the lowest off-take from the Helena Reservoir, and distant 307½ miles therefrom. From the main service reservoir the water flows by gravity to Kalgoorlie, a further distance of 44 miles; the total length of the 30 in. main being 351½ miles. The water is distributed to the various townships and to the mining centres from service reservoirs, and a considerable area of agricultural country is also supplied by branch pipe lines from the main conduit. The area of operations embraces 16,000 square miles, the total length of the water area being approximately 380 miles. The cost of the original works, including expenses of raising loans, was £2,866,454, and of supplementary works £386,247, making a total of £3,252,701. The Mundaring reservoir cost £249,000. Its capacity is 4600 million gallons, and its surface area at full supply level 672 acres. The height of the wall above the river bed is 100 ft.; length of wall, 757 ft.; width of wall at bottom, 85 ft.; at top, 11 ft.; and when the reservoir is full the water runs back for a distance of seven miles.

During the financial year 1910-11 the total consumption amounted to 1,058,900,000 gallons, an increase on the previous year of 57,200,000 gallons. The gross revenue was £237,668, and the working expenses £70,972, leaving a surplus available towards interest and sinking fund of £166,696. The outlay for interest and sinking fund charges in respect of supplementary capital borrowed on debentures absorbed £21,261, leaving £145,435 payable to the State Treasury. During the financial year the State Treasury paid £171,050 interest and sinking fund on State loans in respect of these works, leaving a net deficiency of £25,615.

3. **The Mines Water Supply Branch.**—Prior to the commencement of the Goldfields Water Supply Scheme, works of different kinds were carried out by the Government in order to afford temporary relief to the population on the goldfields. These works comprised shallow and artesian boring, conservation and protection of water in natural and artificial reservoirs, sinking of wells, erection of condensers, etc. About 2000 shallow bores have found fresh water, and a few hundred, salt water, which, however, is serviceable for battery purposes. Administratively, the goldfields area is divided into three water supply districts—Coolgardie, Murchison, and Pilbara. It has been the policy of the department charged with the supervision of water supply works, viz., the Mines Department, to lease watering stations wherever that could be done to advantage, and from twenty to thirty leases are generally executed in the course of a year. The tanks which have been constructed by the department vary in size from 200,000 gallons to 37,500,000 gallons (at Niagara).

§ 2. Artesian Wells.

1. **General.** (i.) *The Great Australian Artesian Basin.* Although there are some artesian wells outside this area, yet, 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 (shewn approximately by map in Section XXVI., Local Government), is said to be the largest yet discovered, and is about 569,000 square miles, of which 376,000 square miles are in Queensland, 110,000 square miles in South Australia, and 83,000 square miles in New South Wales. 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. The basin is what is technically known as a one-sided or half-basin, the intake beds outcropping along its eastern and north-eastern sides only, while the remainder of the water-bearing formation is hidden under the superficial deposits forming the plains of the interior of the States. Although it has not been definitely decided whether the basin has outlets towards the Gulf of Carpentaria in the north, and towards the Great Australian Bight or towards Lake Eyre in the south, there is a preponderance of opinion and strong evidence in favour of the existence of such outlets, an opinion which receives strong support from the maps published by the Geological Department of Queensland, which shew an apparent dip in the water-bearing strata towards the Gulf of Carpentaria in the north and towards Lake Eyre and the Great Australian Bight in the south. It is estimated that at present there are about 1650 bores tapping the basin in the three States.

(ii.) *The Western Australian Basin.* 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 an artesian water area. But 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 area to the west of the Darling Ranges artesian boring has, on the other hand, been carried on successfully for many years.

(iii.) *The South Australian-Victorian Basin.* In August, 1910, a report was issued by the Government Geologist of South Australia on the geology of the country south and east of the Murray River, with special reference to subterranean water supply in wells and bores along the Pinnaroo and Bordertown railways. The tertiary formation in the district under consideration occupies the western portion of a vast basin or depression, of which the greater part extends eastward into Victoria and northward into New South Wales. This basin 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 must exist along the courses of other branches of the River Murray system, where they cut through the tertiary formation.

(iv.) *Plutonic or Meteoric Waters.* While it has long been held that the Australian artesian basin is a typically-formed one, and that its intake beds are as described above, a theory has been recently advanced (viz., by Professor Gregory, [1] formerly of Melbourne, but now of Glasgow University), that the water, although called artesian, is not impounded rain-water, or *meteoric* water at all, but is derived from the older rocks, *i.e.*, that it is *plutonic* in character. If this were so, and if the water contained in the basin were merely such as occurs in the molten lava from volcanoes or imprisoned in the solidified quartz of granites, we should, of course, be rapidly exhausting our supply. He founds his main arguments on (*a*) the amount of friction caused by the flow of water through the minute interstices between the sand grains, *i.e.*, on the loss of its hydrostatic head before the bores are reached; (*b*) on anomalies in temperature and pressure; (*c*) on the chemical analyses of some of the waters; and (*d*) on evaporation measurements in Central Australia. He suggests the pressure of overlying rock, and gas pressure caused by the internal heat of the earth, as causes of the flow from the bores.

This new theory has recently been replied to at length by the Government Geologist of New South Wales.[2] While this Year Book is hardly the place to enter at length upon arguments of a purely scientific nature, it may be said that Mr. Pittman avers that "many of Professor Gregory's statements appear to be in opposition to observed facts." In regard to the loss of hydrostatic head, he quotes the opinion of the United States Geological Survey in regard to bores in Kentucky, and the experience in connection with the Grenelle bore in Paris. So far as temperature is concerned, he shews that it would be illogical to contend that, because some Australian bores give higher rates of increase than the average results of a number of ascertained bores and tunnels in other parts of the world, the water must be plutonic and not meteoric. In regard to pressure, stress is laid on the more accurate results obtained with the dumpy level than with the aneroid, and it is shewn how accurately the height to which the water would rise has been

1. See *J. W. Gregory, F.R.S., D.Sc.*: "The Dead Heart of Australia"; London, John Murray, 1906.

2. *E. F. Pittman, A.R.S.M., 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).

predicted in many localities. It is also pointed out that the isopotential lines as laid down are tentative, as information in regard to many private wells is unreliable. The question of the chemical constituents of artesian water is dealt with at length, and it appears that instead of decreasing from east to west, as stated by Professor Gregory, the salinity of the water actually increases, and that some of the wells in the eastern district mentioned by the latter as being particularly rich in saline matter are actually outside the artesian basin altogether.

In regard to evaporation measurements in Central Australia, Mr. Pittman holds that these do not affect the question at issue at all, as the water does not enter the porous beds in Central Australia, but on the flanks of the Dividing Range, where the rainfall is copious. The theories of the pressure of overlying rock and of gas pressure are not accepted by him.

The strength of the argument seems to be unquestionably in favour of the older theory of meteoric water, as upheld by Mr. Pittman. Professor Gregory has made a rejoinder entitled "The Flowing Wells of Central Australia," which appeared in *The Geographical Journal* for July-August, 1911.

(v.) *Particulars of Artesian and Sub-artesian Bores, 1910.* The following table gives particulars of artesian and sub-artesian bores in each State and in the Commonwealth up to the end of the year 1910:—

COMMONWEALTH AND STATES.—PARTICULARS OF ARTESIAN AND SUB-ARTESIAN BORES, 1910.

Particulars.	N.S.W.	Victoria.	Q'land.	S. Aust.†	W. Aust.	Tas.	C'wlth.
Bores existing ... No.	445	31	1,711‡	73	79	...	2,339‡
Total depth bored ... feet	724,274	8,873	1,762,500	69,432	79,600	...	2,644,679
Daily flow ... ,000 gals.	67,556†	*	516,591	8,806	27,938	...	620,891
Depth at which artesian water was struck—							
Maximum ... feet	4,341	436	5,045	4,850	3,011	...	5,045
Minimum ... feet	46	131	10	130	56	...	10
Temperature of flow—							
Maximum ... °Fahr.	139	*	202	208	140	...	208
Minimum ... °Fahr.	70	*	81	82	60	...	60

* Not available. † Government bores only. ‡ See footnotes to table at bottom of page 587.

2. **New South Wales.**—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. At the end of 1910, out of 445 known artesian bores in New South Wales, 189 were Government bores.

The distribution of these bores was as follows:—

NEW SOUTH WALES ARTESIAN BORES ON 31st DECEMBER, 1910.

Particulars.	State.	Private.	Total.
Bores existing ... ... No.	189	256	445
Total depth bored ... ... feet	358,632	365,642	724,274
Daily flow ... ... gallons	67,556,515*	†	†
Depth at which water was struck—			
Maximum ... ... feet	4,341	3,550	...
Minimum ... ... ,,	89	46	...
Temperature of flow—			
Maximum ... ... °Fahr.	139	130	...
Minimum ... ... ,,	70	71	...

* Excluding the flow from eighteen bores, the particulars of which are not available.
† Not available.

Of the wells at the end of 1911, the depth is stated in 487 cases, and it appears that only 21 wells were less than 500 feet deep; while 88 ranged from 500 to 1000 feet; 239 from 1000 to 2000 feet; 102 from 2000 to 3000 feet; 32 over 3000 feet; and five over over 4000 feet. There is a preponderance of wells from 1000 to 2000 feet in depth, but neither the shallow wells under 500 feet, nor the very deep wells over 3000 feet are so numerous in proportion as in Queensland. The two deepest wells in New South Wales are those at Boronga, in the County of Stapylton, with a depth of 4341 feet and a daily outflow of 1,062,133 gallons; and at Dolgelly, in the Parish of Careunga, in County Stapylton, with a depth of 4086 feet, and an outflow of 622,185 gallons per day. The largest outflow is stated to be that at the Boobora bore, in the County of Stapylton, which yields 1,133,300 gallons a day, and has a depth of 3225 feet.

The Zetz Spa, much used as a mineral water in New South Wales, comes from Ballimore, near Dubbo.

It may be said that the cost of artesian wells works out at an average of about 20s. per lineal foot; it depends, of course, upon the depth to which boring operations have to be extended, and on the accessibility of the bore to a railway station. The practice is to line the bore with three strings of casing, ten, eight and six inches in diameter respectively. The ten and eight inch strings are inserted as far as may be considered necessary, and the six-inch string generally taken to the bottom of the bore. Recent contract prices per lineal foot for a bore complete are as follows:—To 1000 feet, 27s. per foot; 1000 to 1500 feet, 17s. 9d:; 1500 to 2000 feet, 18s. 3d.; 2000 to 2500 feet 19s. 3d.; 2500 to 3000 feet, 21s. 3d.; 3000 to 3500 feet, 23s. 9d.; 3500 to 4000 feet, 30s. The increased cost per lineal foot for the first 1000 feet is owing to the insertion of the three strings of casing.

3. **Victoria.**—Victoria lies altogether outside the Great Australian Artesian Basin, and as water is obtainable in most parts of the State at shallow depths, there has not been much occasion for artesian boring. As early as 1884, however, an artesian well was bored at Sale, which for a number of years gave a supply of about 100,000 gallons per day until, either through corrosion of the casing or by choking up with sand from below, the flow ceased. In 1905 a new bore was therefore put down, which at a depth of 277 feet yielded sufficient water to fill Lake Guthridge, a local depression. But as the water was impure, and contained too much 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, which at present is stated to be about 145,000 gallons per day. Further trouble, however, has been experienced owing to failure of casing and a fresh bore is being prepared.

In the late eighties a number of bores were put down in the North-Western part of the State varying from 200 to over 2000 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 forty-two bores have been sunk, thirty-eight of which have been successful. Their depths vary from 150 to 475 feet, and the water rises to within from 200 to 7 feet of the surface. In one instance the bore flows, the water rising to four feet above the surface. The fresh water extends as far east as the 142nd meridian and its northern limits are not yet ascertained. Information as to the geological formation of this district is given on page 584 preceding.

At the end of 1910 the number of existing Government bores in use in Victoria was 31, from which supplies are obtained by pumping. The total depth bored amounted to 8873 feet, while the maximum and minimum depths at which water was struck were 436 and 131 feet respectively.

4. **Queensland.**—The publication of the reports issued annually by the Hydraulic Engineer of Queensland has been suspended during the last eight years, and these reports are only available to 30th June, 1902. At that date the following bores were in existence :—

QUEENSLAND ARTESIAN BORES ON 30th JUNE. 1902.

Sunk by—	Artesian Flows.	Sub-Artesian Flows.	Pumped Supplies.	In Progress, Abandoned, Uncertain.	Total.
Water Supply Department (trial borings)	22	...	3	24	49
Railway Department	2	...	2	13	17
Local governing authorities	10	...	15	5	30
Private owners	530	9	131	168	838
Total ...	564	9	151	210	934

The depth of 850 of these wells is given, and it appears that there were 229 less than 500 feet deep, 200 from 500 to 1000 feet, 231 from 1000 to 2000 feet, 124 from 2000 to 3000 feet, and 66 over 3000 feet. The deepest well was one known as Bimerah Run No. 3, Whitewood, lying between the Barcoo and Thomson Rivers ; this had a depth of 5045 feet, and was stated to yield 70,000 gallons daily. This flow is, of course, a comparatively small one, many wells yielding, when uncontrolled, from one to three million gallons a day. A well at Cunnamulla is stated to have a daily flow, when uncontrolled, of no less than 4,500,000 gallons. The waters of many of the wells have been analysed, 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 water known as " Helidon Spa," which is much in use in Queensland and New South Wales, are shallow wells from 60 to 200 feet in depth.

The following table shews particulars as to Queensland bores at the end of June, 1911 :—

QUEENSLAND ARTESIAN BORES ON 30th JUNE, 1911.

Particulars.	State and Local Athorities.	Private.	Total.
Bores existing ... ... No.	268*	1,443†	1,711
Total depth bored ... ... feet	188,140	1,574,360	1,762,500
Daily flow ... ... gallons	35,562,200	481,029,000	516,591,200
Depth at which artesian water was struck—			
Maximum ... ... feet	4,256	5,045	...
Minimum ... ... ,,	614	10	...
Temperature of flow—			
Maximum ... ... °Fahr.	173	202	...
Minimum ... ... °Fahr.	92	81	...

* 54 flowing, 45 pumped, 151 abandoned or uncertain.
† 731 flowing, 284 pumped, 428 abandoned or uncertain.

5. **South Australia.**—The information about artesian wells is somewhat meagre. Early in 1908 a list of twenty-five of the principal Government bores was published, of which four were under 1000 feet in depth, twelve from 1000 to 2000 feet, two from 2000 to 3000 feet, and seven over 3000 feet. The deepest flowing well was at Goyder's Lagoon, on the Hergott to Birdsville route, measuring 4580 feet, and yielding 600,000 gallons per day. A bore at Patchawarra, 35 miles north of Innamincka, was in September, 1909, down to 4863 feet, but had not at that depth struck the subterranean water. The maximum flows, viz., 1,250,000 gallons and 1,000,000 gallons daily, occurred at Coward Springs and Dulkaninna respectively.

The following table shews particulars as to South Australian bores at the end of December, 1910:—

SOUTH AUSTRALIAN BORES, 1910.

Particulars.	Artesian.	Sub-artesian.	Total.
Bores existing	26	47	73
Total depth bored ... ... feet	47,375	22,057	69,432
Daily flow ... ... gals.	8,806,000	†	...
Depth at which water was struck—			
Maximum ... ... feet	4,850	2,002	...
Minimum ... ... feet	233	130	...
Temperature of flow—			
Maximum ... ... °Fahr.	208	†	...
Minimum ... ... °Fahr.	82	†	...
Total cost of construction of bores up to end of year	£138,042	£66,995	...
Expenditure during year on boring operations	£11,294	†	...

† Not available.

(i.) *Bores along Bordertown Railway.* 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 ft., none was reported to have been struck. Ki Ki bore was sunk in 1887 and at 361 ft. 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.

The following table gives particulars relating to bores along the Bordertown railway. In all these bores water was found in porous beds of Eocene (Tertiary) age.

SOUTH AUSTRALIA.—PARTICULARS OF BORES ALONG BORDERTOWN RAILWAY, 1910.

Bore.	Elevation of Surface above Sea-level.	Depth of Water.	Depth of Water-level from Surface.	Quality; Salts and Matter per Gallon.	Supply per diem.	Remarks.
	Ft.	Ft.	Ft.		Gallons.	
Cooke's Plains	17	15	...	Salt	...	Bottomed granite, 218 feet.
Ki Ki ...	68	73 361	68	Brackish	16,800 16,800	Bottomed decomposed slates, 450 ft.
Tintinarra ...	62	251	(Rises to surface).	Fresh (81 grs.)	4,300	...
Emu Flat ... Keith ...	100	52 166 264	28	Fresh (98 grs.)	8,500	At 60 ft. from surface 312,000 gals. per diem.

(ii.) *Bores along and near Pinnaroo Railway Line.* The subjoined table gives particulars of some of the principal bores in the Pinnaroo country. In 1904 the first bore was sunk in this district at Cotton; numerous successful bores have since been put down by the Public Works Department, and subsequently by the residents of the district. Several wells, ranging in depth from 55 ft. to 221 ft., have also been sunk in this district.

SOUTH AUSTRALIA.—PARTICULARS OF PRINCIPAL BORES NEAR PINNAROO RAILWAY LINE, 1910.

Bore.	Elevation of Surface above Sea Level.	Depth of Water.	Depth of Water Level from Surface.	Quality.	Salts per Gallon.	Supply per diem where ascertained.
	Feet.	Feet.	Feet.		Grains.	Gallons.
Sherlock ...	53	270	15	Fresh	196.24	...
Geranium ...	240	140	140	,,	96.05	14,400
Cotton ...	300	190 and 800	170	,,	81.16	30,000*
Parilla ...	340	207 and 250	207	,,	...	...
Bews ...	350	227	193	,,	...	10,800
Clay Pan ...	340	225	203	,,	...	13,440
Kow Plains...	344	140 and 210	167	,,	73.79	...
Fuller ...	100	72 and 340	43 and 29	Brackish / Fresh	101	...
Gosden ...	100	327	27	Fresh	...	48,000

* Bottomed on granite at 839 feet.

The latest Government bore is situated 7½ miles south of Brown's well, near the terminus of the proposed railway from Tailem Bend. The depth of this bore is 220 ft., and the water, which is in large supply, rises to within 52 ft. of the surface. The water is fresh, containing ¼ oz. salts and other solid matter per gallon.

6. **Western Australia.**—As already stated, no artesian water has been found east of the Darling Ranges, although a large number of shallow bores yield either fresh or salt water.

At the end of the year 1910 the total number of bores west of the Darling Range was 79, of which 47 were Government bores. The total depth bored is given as 48,349 feet in Government and 31,251 feet in private bores. The total cost of construction of State bores at the end of the year 1910 was about £33,000, of which amount £13,000 was spent in 1910. The total daily flow of the Government bores is stated as 15,532,310 gallons, and of private bores as 12,406,400 gallons. The maximum and minimum depths of State bores were 3011 feet and 56 feet respectively, and the maximum and minimum temperatures 140° and 60° Fahrenheit. The maximum outflow, 1,167,000 gallons per day, is said to be obtained from a well at Guildford.

§ 3. Irrigation Plants.

1. **General.**—Various causes have combined to keep proposals for irrigation works on a large scale before the Parliaments of several of the States for a number of years without any very tangible results, except in the case of New South Wales, Victoria, and South Australia. The absence of the example of any country which has constructed such works under similar climatic and labour conditions, the very partial success of some of the smaller works undertaken in Australia, and the abundant supply of artesian water obtained during the last twenty years in parts of the continent most liable to droughts, have all tended to delay the undertaking of large works.

2. **New South Wales.**—(i.) *Irrigation Trusts.* The first action by the Government of this State for the establishment of irrigation settlements was taken under Acts of Parliament, which authorised the formation of irrigation trusts in the vicinity of Wentworth in 1890, Hay in 1892, and Balranald in 1893. The Wentworth Trust controlled an area of 10,600 acres, but has been dissolved and its powers assumed by Government. A pumping plant has been provided and channels laid out for the irrigation of an area of 1500 acres, of which 1000 acres are at the present time under successful occupation, largely for the production of horticultural crops and a small amount of lucerne. The original area under the Hay Trust was 12,847 acres, but in 1896 this was reduced to 3000 acres. The pumping plant and channels provide for the irrigation of 900 acres, which are under occupation, principally in connection with the growth of fodder crops for dairying, a small area being under horticultural crops. No works for the supply of water have yet been carried out by the Balranald Trust, which controls an area of 1000 acres. It is improbable that any irrigation will be provided in this area in the near future.

(ii.) *Private Irrigation.* Irrigation by private individuals is almost entirely carried out by pumping plants licensed under the provisions of the Water Rights Act. The largest plants draw their supplies from the River Murray for irrigating areas of from 600 to 700 acres of lucerne grown for stock feeding purposes.

(iii.) *The Murrumbidgee Northern Irrigation Scheme.* This scheme provides for the utilisation of a large proportion of the waters flowing from the Murrumbidgee catchment area in normal seasons. The works which are necessary to provide for the conservation of these waters consist in the first place of a large storage reservoir in which the water is to be retained by a weir known as the "Burrinjuck Dam." This dam is being constructed across the channel of the Murrumbidgee River, about three miles below the confluence of the Goodradigbee River. The catchment area above this point is 5000 square miles.

The retaining wall will have a total height of 240 feet from its crest to the deepest foundation level; the total length will be 784 feet curved in plan to a radius of 1200 feet; the thickness at the crest will be 18 feet and at the base 170 feet. The maximum depth of the water stored will be 224 feet, the total volume being 33,630 million cubic feet. The wall itself will contain about 600,000 tons of material, and will require about 50,000 tons of cement for its construction. The work is now partially completed and it is estimated that it will be finished in 1913. The object of constructing this weir is to regulate the supply of water, so that the large volumes which are afforded by the winter rains and the melting snows of the spring may be retained and made available to supplement the natural flow of the river in the dry months of the summer, when irrigation water is most required. The volumes of water thus made available for irrigation requirements will be conveyed in the channel of the Murrumbidgee River for a distance of 200 miles from the storage to a point above the town of Narrandera at Berembed, where a reservoir known as the Berembed Weir is in course of construction with the object of diverting supplies by gravitation into the irrigation lands. A main canal, capable of carrying 1000 cubic feet per second, is being constructed from the Berembed weir for the purpose of conveying the waters to the irrigable lands situated along the base of the hills to the west of the town of Narrandera.

It is proposed that the State Government shall acquire and subdivide for the purposes of intense culture the whole of these irrigable areas, which consist of about 200,000 acres of first-class and 360,000 acres of second-class land. The main canal will be capable of carrying to these areas only about one half of the water which will be made available for irrigation by the construction of the Burrinjuck dam. No determination has yet been arrived at as to whether the additional available volumes will be utilised for irrigating further areas of these same lands on the northern side of the river, or whether a separate canal will be constructed for the purpose of carrying supplies to lands on the southern side.

It is stated that the conditions as regards water-supply, soil, and climate are such as to ensure the success of the scheme, and it is anticipated that when the whole of the lands are settled there will be an addition of at least 50,000 people to the population within the district. It is expected that, in addition to the horticultural crops which will be grown, the supplies of fodder which will be afforded by the irrigation settlement will be sufficient to obviate the evil effects of droughts in the surrounding pastoral districts and will thus largely increase their stock-carrying capacity and productiveness.

(iv). *Other Irrigation Schemes.* The following proposals are under investigation by the State Irrigation Department :—

(*a*) *Lachlan River.* The construction of a storage reservoir on this river at a place known as Wyangala, below the confluence of the Abercrombie River, for the purpose of affording water in the river channel for pastoral purposes and for the irrigation of small areas along the river banks by pumping.

(*b*) *Macquarie River.* The construction of a storage reservoir on this river at Burrendong below the confluence of the Cudgegong River, for the purpose of affording water by gravitation for the irrigation of certain lands to the west of Narromine.

(*c*) *Murray River.* The construction of a storage reservoir across the Murray River at Camberoona, above Albury, in order to supply water by gravitation through a canal which will be taken off at Bungowannah, below Albury, for the irrigation of high-class lands lying between the Murray and the Billabong Creek near the town of Berrigan.

(*d*) *Hunter River.* The construction of storage reservoirs on the Upper Hunter or Goulburn River with a view to supplying water by pumping from the Hunter River to the adjoining lands and supplementing the water supply of Newcastle. It is stated that the valley of this river is one of the most fertile districts in the State and that it is capable of carrying a dense population under the conditions of intense culture by irrigation.

(*e*) *Darling River.* The conversion of Lake Menindie into a large permanent storage by means of a diversion weir across the Darling River and of a canal through Lake Pamamaroo, the water so stored to be utilised in the irrigation of the bed of Lake Cawndilla and of certain lands to the south-west.

(*f*) *Warragamba River.* A scheme has been prepared for the construction of a large storage dam on the Warragamba River, so as to retain a depth of 225 feet and a volume of 103,000 million gallons of water. This would be available for the supply of 80 million gallons daily for the domestic services of Sydney, 30 million gallons daily for trade purposes, and 80 million gallons daily for irrigation purposes in the county of Cumberland.

It is proposed that the water for domestic purposes should be conveyed and delivered at Potts Hill through 48 miles of open concrete channel and pipes; that the supplies for trade purposes should be delivered in the vicinity of the Great Western Railway, between St. Mary's and Penrith; and that the lands situated along the banks of the Nepean River and in the valley of South Creek should be irrigated.

3. **Victoria.**—(i.) *Classification of Works.* The Water Conservation Works in Victoria naturally divide themselves into those providing mainly a domestic supply, such as the Yan Yean works, controlled by the Melbourne and Metropolitan Board of Works; the Coliban, Broken River, Kerang Lakes, and Mallee Supply Works, which, although now administered by the State Rivers and Water Supply Commission, are properly local

government works; other works for domestic supply controlled by Water Works Trusts or Municipal Corporations; and irrigation works proper. With the exception of the last-named class particulars as to these works will be found in the section on "Local Government" of this book.

(ii.) *Works Controlled by the Commission.* With the exception of the First Mildura Irrigation and Water Supply Trust, all of 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, which was created by the Water Act 1905, in force since 1st May, 1906. The works under the control of this body, which is composed of three members, may be classified as follows:—(*a*) Irrigation schemes; and (*b*) Domestic and stock schemes included in which are a number for providing town supplies, the principal being the Coliban system. The following statement shews the capital cost of each class of works under the control of the commission:—

VICTORIA.—COST OF WORKS VESTED IN, AND UNDER CONTROL OF, STATE RIVERS AND WATER SUPPLY COMMISSION, 1911.

Particulars.		Irrigation Schemes.	Domestic and Stock Schemes including Town Supplies.	Miscellaneous.	Total.
Capital cost ...	£	2,889,479	1,989,525	66,547	4,945,551

(*a*) *Irrigation Schemes.* This division comprises the schemes constructed and under construction for the supply of water to between twenty to thirty irrigation districts. Up to 1906 these schemes were controlled by local Trusts which had obtained the moneys for the construction on loans from the State. By the Water Act 1905 all local control was abolished and the districts were transferred to the State Rivers and Water Supply Commission. Since this date the Government has adopted a vigorous irrigation policy and the expenditure on construction during the past four years amounts to £1,250,000. The irrigation works draw their supplies mainly from headworks constructed on the Murray, Goulburn, and Loddon rivers. The cost of these works, which now stands at £1,087,000, is not debited to the districts benefited, but is borne entirely by the State. Within the last two years the State has adopted the policy of purchasing large areas of land commanded by these schemes and subdividing them for intensive culture. The settlement of the areas on these lines will mean a large increase in the population of the State.

(*b*) *Domestic and Stock Schemes.* The second division takes into account the schemes constructed and under construction for the supply of water for domestic and stock purposes to very large tracts of country. The principal works of this division are situated in the Wimmera and Mallee districts, and cover an area of about 6000 square miles. The loan expenditure for 1901-11 within this area amounted to between £50,000 and £55,000, while for 1911-12 it is estimated that the expenditure will amount to over £60,000. In addition to the Commission's districts some large areas are still administered by local authorities.

It should be mentioned that in 1899 the State deemed it advisable to write off the sum of £1,073,000 from capital accounts of the local bodies then controlling the works in each of the above divisions.

(iii.) *Mildura.* The first settlement of Mildura dates from 1884. After being managed until 1887 by Chaffey Bros., and then until 1895 by Chaffey Bros. Company Limited, it was in that year taken over by the First Mildura Irrigation Trust and has since then made great progress. Its population, at the Census of 1911, was 6145. For

the year ending 30th June, 1910, the receipts of this Trust aggregated £21,329, and its expenditure £16,466. For the same period the area of land under cultivation and the record of water acres were 12,189 and 35,475 acres respectively.

No precise figures are available as to the capital cost of the works at Mildura; probably the sum was not less than £180,000. The amount due to Government is £72,430, exclusive of £15,434 for accumulations of interest.

(iv.) *Lands supplied with water within the State.*—The area of country lands within the State artificially supplied with water for domestic and ordinary use and for watering stock is approximately 17,000 square miles, equal to 10,880,000 acres. The extent of land under irrigated culture, for all kinds of crop, is 142,857 acres, an increase of 13,086 acres over the area irrigated in the previous year. About 11,000 acres have been watered under yearly permits granting authority to divert water from streams throughout the State. Further progress has been made during the year in bringing all such diversions under the control of the Commission, 469 permits authorizing diversions for irrigation, domestic and stock, and power purposes being now in force.

4. **Queensland.**—The main irrigation works in Queensland are as follow:—(*a*) those at Ayr, which utilise the waters of the Burdekin River, and shallow wells on its banks; (*b*) those at Bingera, near Bundaberg, which utilise water pumped from the Burnett River just above the point of meeting of the salt and fresh waters, and (*c*) those at Fairymead, which utilise water pumped from a number of shallow spear wells sunk on the alluvial flats on the north side of the Burnett River and about six miles from Bundaberg. Apart from the persons benefiting from the two schemes mentioned, there were said to be not more than 363 irrigators in 1909, chiefly farmers and graziers, in the State.

5. **South Australia.**—(i.) *The Renmark Irrigation Trust.* The Renmark Irrigation Trust was established on similar lines to Mildura, but on a considerably smaller scale. At present the extent of the land assessed for the purpose of the trust is approximately 5200 acres, and maintains a population of about 2000. The value of Renmark products averages about £100,000 per annum. It is claimed that without irrigation the land would barely feed 500 sheep.

(ii.) *Other Waterworks.* The Bundaleer reservoir consists of a large earth and clay embankment which impounds water in a natural basin away from the main watercourses. Its capacity is stated at 1,319,000 gallons.

The Barossa waterworks have a reservoir wall of concrete seventy-five feet in height. The reservoir has a holding capacity of 993,340,000 gallons.

A reservoir, the first in the northern part of the State, was completed at the end of 1909 on Pekina Creek, above Orroroo.

The largest of the South Australian undertakings is the Beetaloo waterworks, which supply the towns of Port Pirie, Moonta, Wallaroo, Kadina, and fifteen others, besides one million acres of country lands. The cast-iron reticulation pipes in connection with Beetaloo are 637 miles in length, and the capital cost of the works was £989,950.

None of the South Australian works, Renmark excepted, are, however, irrigation works properly so called, although they are to some extent used for irrigation purposes.

(iii.) *Area under Irrigation.* The area under irrigation in South Australia, including reclaimed lands along the Murray, amounted to only 20,000 acres at the beginning of 1911. The Government, however, proposes to push on with the irrigation schemes along the Murray as fast as possible. The Cobdogla station, held under grazing permits, will be the next area taken in hand, and notice for the resumption of 118 square miles has been given to the present occupiers. The area comprises practically the whole of the original Lake Bonney irrigation scheme, and is contiguous to the Berri irrigation area, which contains a further 19,000 acres of the Cobdogla run. It is proposed to start

the reticulation with channels for an area of 5000 acres, between the Cobdogla homestead and Lake Barmera (formerly Lake Bonney), which lends itself to economical irrigation. A large central pumping station will be erected at the south end of the lake, and will command the whole of the irrigation area, including the 5000 acres, the maximum lift being about 90 feet.

6. **Conflicting Interests.**—The relative rights of the States of New South Wales, Victoria, and South Australia to the waters of the Murray River are undetermined. Territorially the south bank of the Murray was the boundary between the two former States, *i.e.*, the region of the river itself, up to the point where it enters South Australia, was wholly within New South Wales.

At the Federal conventions which preceded the establishment of the Commonwealth the South Australian representatives expressed their fear lest too much irrigation on the Murray and Darling might impair the navigability of the latter river, and the result was the insertion of a provision in the Commonwealth Constitution which reads as follows:—

"*Section 100.*—The Commonwealth shall not, by any law or regulation of trade or commerce, abridge the right of a State or the residents therein to the reasonable use of the waters of rivers for conservation and irrigation."

Under this section negotiations have for several years been in progress between the three interested States. In January, 1911, a conference took place in Melbourne between the Premiers of New South Wales, Victoria, and South Australia on the Murray Waters question. One of the primary objects of this conference was to discuss the provision in the Murray Works Act, passed by the South Australian Government in 1910, authorising the carrying out of certain works at Lake Victoria in New South Wales subject to an agreement being made for the acquisition by South Australia of the lake together with the two watercourses, known as Rufus River and Frenchman's Creek, connecting the River Murray with the lake. The Premier of South Australia claimed the right to have enough water sent down the river to maintain navigation, and also asserted a right to the waters flowing down the Goulburn in Victoria, and the Murrumbidgee in New South Wales, into the Murray, as well as to the waters of the Murray itself, not only for navigation, but also for the irrigation purposes contemplated by the Government of South Australia. In support of the navigation proposal it was stated that South Australia had in view a scheme for cutting a canal from the Murray to Victoria Harbour, with harbour improvements, etc., which altogether would cost a million sterling. Briefly stated, the results of the conference were that South Australia was to be allowed to carry out storage works at Lake Victoria, New South Wales, and lock her own portion of the Murray at her own expense, but New South Wales and Victoria would not recognise the claims of navigation in any way, and would not bind themselves to deliver any quantity of water at the point of intake into South Australia. No rights to navigation were conceded by New South Wales and Victoria, and the upper portions of the river were left free for irrigation. The storage works which the South Australian Government proposes to construct at Lake Victoria will cost about £162,000, and the total scheme, which will include the construction of at least five locks, will cost between £600,000 and £700,000. It is estimated that as the result of the storage works 22,000,000,000 cubic feet of water can be impounded in Lake Victoria. It is stated that there will be no difficulty in filling the lake in the winter months.