CHAPTER IX.

WATER CONSERVATION AND IRRIGATION.

A. RESOURCES, UTILIZATION AND NATIONAL AND INTERSTATE ASPECTS.

§ 1. Introduction.

Official Year Book No. 37, pp. 1096–1141, contained a special article "The Conservation and Use of Water in Australia" prepared by Mr. Ulrich Ellis of Canberra. In subsequent issues, much of Mr. Ellis's article of a statistical nature has been advanced, as has the general information on the more important developments in this field, but for details of general, descriptive and historical matter reference should be made to the original article. Appended to the special article was a bibliography of selected books, reports, papers, etc., dealing with the development of the water resources of Australia and their conservation (*see* pp. 1140–41).

For further details on geographical and climatic features determining the Australian water pattern, reference should be made to Chapter II.—Physiography; on water supply and sewerage in metropolitan areas, cities and towns to Chapter XIX.—Local Government; and on the generation of hydro-electric power to Chapter VIII.—Electric Power Generation and Distribution, of this issue.

A series of maps showing the location of major dams and reservoirs and the various irrigation schemes operating in each of the States was published on pp. 1073–9 of Official Year Book No. 40.

A map showing the extent of known artesian basins throughout Australia is shown on page 307 of this Year Book.

§ 2. Water Resources and their Utilization.

1. **Surface Supplies.**—Though river gaugings have been recorded over considerable periods in some parts of Australia, records elsewhere are intermittent, of short duration, or non-existent. At present, therefore, it is impossible to estimate, with any degree of reliability, the total average annual flow of Australian streams, but it would probably amount to only a small figure in comparison with the flow of rivers in other continents, some examples of which, expressed as mean annual discharges in millions of acre feet, are: Nile, 72; Danube, 228; Amazon, 1,780; Volga, 148; Mississippi, 474; and the ten main rivers of the United States of America, 900 (in the aggregate).

2. **Major Dams and Reservoirs.**—*The table below lists existing major dams and reservoirs together with those under construction or projected as at June, 1956.*

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA.

Name.	Location.	Capacity (Acre feet).	Height of Wall (Feet)	Remarks.
EXISTING DAMS AND RESERVOIRS.				
Eildon	Upper Goulburn River, Victoria	2,750,000	250	Earthen embankment 3,300 feet long. Storage for irrigation and for the generation of electricity.
Hume	Murray River near Albury	1,382,000	110	Part of Murray River Scheme—storage for domestic, stock and irrigation purposes. Being increased to 2,500,000 acre feet. Hydro-electric power to be developed.
Miena	Great Lake, Tasmania	1,125,000	40	Regulates water to Waddamana hydro-electric power station.
Burrinjuck ..	Murrumbidgee River, New South Wales	837,000	264	Storage for irrigation and production of hydro-electric power.
Somerset	Stanley River, Queensland	735,000	173	Brisbane–Ipswich water supply, flood mitigation and small hydro-electric power station.
Lake Victoria ..	Murray River near South Australian border, in New South Wales	551,700	..	Natural storage for irrigation in South Australia.

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA—*continued.*

Name.	Location.	Capacity (Acre feet).	Height of Wall (Feet).	Remarks.
EXISTING DAMS AND RESERVOIRS—*continued.*				
Lake Echo ..	Lake Echo, Tasmania	398,600	60	Storage for Lake Echo and Tungatinah hydro-electric power stations.
Waranga	Goulburn River, Victoria	333,400	..	Earthen embankment, 23,800 feet long. Irrigation storage.
Wyangala ..	Lachlan River, New South Wales	303,900	190	Storage for domestic, stock and irrigation purposes and for generation of hydro-electric power.
Rocklands ..	Glenelg River, Victoria	272,000	..	Part of Wimmera-Mallee domestic and stock water supply system.
Clark	Derwent River, Tasmania	243,000	200	Serves Tarraleah hydro-electric power station.
Avon	Nepean River, New South Wales	173,800	232	Part of Sydney water supp y.
Lake Brewster ..	Lachlan River, near Hillston, New South Wales	123,900	..	Storage of rural water supplies for the lower Lachlan.
Cairn Curran ..	Loddon River, Victoria	120,600	..	Storage for irrigation.
Glenmaggie ..	Gippsland, Victoria	106,000	100	Storage for irrigation.
DAMS AND RESERVOIRS UNDER CONSTRUCTION OR PROJECTED.				
Burdekin Falls ..	Burdekin River, North Queensland	6,584,000	150	Projected for generation of hydro-electric power, irrigation and flood mitigation.
Adaminaby ..	Eucumbene River, New South Wales	3,500,000	390	Under construction as part of Snowy Mountains Hydro-electric Scheme.
Menindee Lakes Project	Darling River near Menindee, New South Wales	2,000,000	..	Part of Darling River water conservation scheme—under construction.
Warragamba ..	Warragamba River, New South Wales	1,694,900	373	Under construction for Sydney water supply. Also provides for generation of hydro-electricity and flood mitigation.
Jindabyne ..	Snowy River, New South Wales	1,100,000	274	Projected as part of Snowy Mountains Hydro-electric Scheme.
Burrendong ..	Macquarie River, near Wellington, New South Wales	914,000	193	Under construction for rural water supplies.
Blowering ..	Tumut River, New South Wales	800,000	300	Projected as part of Snowy diversion scheme.
Tantangara ..	Murrumbidgee River, New South Wales	616,500	215	Projected as part of Snowy Mountains Hydro-electric Scheme.
Warkworth ..	Wollombi Brook (Hunter Valley), New South Wales	400,000	100	Projected as a flood mitigation dam for the Hunter Valley.
Keepit	Namoi River, near Gunnedah, New South Wales	345,000	135	Under construction for rural water supplies.
Tinaroo Falls ..	Barron River, North Queensland	320,000	133	Under construction for irrigation purposes in the Mareeba–Dimbulah area.
Glenbawn ..	Hunter River, near Scone, New South Wales	296,000	240	Under construction as part of Hunter Valley conservation work.
Wellington ..	Collie River, Western Australia	150,000	110	Existing dam to be enlarged for supply of water to irrigation districts and to agricultural areas and towns.
Koombooloomba ..	Tully River, North Queensland	146,000	123	Under construction for hydro-electric and possibly irrigation purposes.
Upper Yarra ..	Yarra River, Victoria	110,000	270	Under construction for Melbourne water supply.

The maps on pp. 1073–9 of Official Year Book No. 40 show the positions of the abovementioned dams and reservoirs.

3. **Irrigation.**—(i) *History.* For some brief remarks on the history of irrigation in Australia referring to the efforts of the Chaffey Brothers and to the Victorian Irrigation Act in 1886 *see* issues of the Official Year Book prior to No. 39. Trends in irrigation practice in more recent years were described in Official Year Book No. 37, p. 1009.

(ii) *Extent and Nature of Irrigated Culture.* About half of Australia's irrigated acreage is in Victoria, and about two-thirds is situated along the Murray and its tributaries (including the Murrumbidgee) in the three States of New South Wales, Victoria and South Australia. In these areas served by the Murray and its tributaries, irrigation water is used extensively for vines, orchards, pastures, fodders, and for domestic and stock purposes. Approximately half of Queensland's irrigated acreage is devoted to sugar cane. Western Australia's small irrigated acreage is confined to areas in the south-west where vegetables, orchards, fodders, and pastures are served. Large scale irrigation schemes have not been developed in Tasmania or the Northern Territory although reference is made on page 322 to investigations at present being carried out in the Northern Territory to determine the availability of irrigation water for rice production.

The following table shows the area of land irrigated in each State during the years 1950–51 to 1955–56 :—

AREA OF LAND UNDER IRRIGATED CULTURE.

(Acres.)

Season.	N.S.W. (*a*)	Vic. (*b*)	Q'land.	S. Aust.	W. Aust.	Tas.	N.T.	A.C.T.	Aust.
1950–51 ..	597,773	716,051	83,150	79,062	28,197	7,242	..	468	1,511,943
1951–52 ..	596,601	723,797	113,040	58,427	29,106	6,830	..	656	1,528,457
1952–53 ..	494,900	755,030	126,693	57,057	31,067	8,414	..	606	1,473,767
1953–54 ..	540,243	821,025	146,282	62,062	34,247	9,412	..	800	1,614,071
1954–55 ..	616,264	863,563	139,414	69 452	36,130	13,761	151	791	1,739,526
1955–56 ..	379,611	634.334	136,019	70,987	37,164	11,499	225	774	1.207,613

(*a*) Source : Water Conservation and Irrigation Commission. (*b*) Source : State Rivers and Water Supply Commission.

The next table shows the area of land irrigated in each State during 1955–56 according to the nature of irrigated culture.

AREA OF LAND UNDER IRRIGATED CULTURE, 1955-56.

(Acres.)

Crop.	N.S.W. (*a*)	Vic. (*b*)	Q'land.	S. Aust.	W. Aust.	Tas.	N.T.	A.C.T.	Aust.
Rice	41,837	..	..	..	..	..	..	..	41,837
Vegetables ..	16,658	16,330	19,828	10,358	6,880	1,125	55	146	71,380
Fruit	18,142	35,452	3,671	16,248	4,768	605	74	8	164,362
Vineyards ..	12,960	45,518		26,453	463	..	..	..	
Sugar-cane ..	(*c*)	..	58,762	..	..	..	..	..	58,762
Hops	..	(*c*)	..	..	..	1,248	..	..	1,248
Cotton	..	..	685	..	..	..	..	..	685
Other Crops (including Fodder and Fallow land)	70,043	30,891	(*d*)29,511	3,548	1,725	1,231	96	420	137,465
Total, Crops	*159,640*	*128,191*	*112,457*	*56,607*	*13,836*	*4,209*	*225*	*574*	*475,739*
Pastures ..	219,971	*e* 506,143	23,562	(*e*)14,380	23,328	7,290	..	200	794,874
Total ..	379,611	634,334	136,019	70,987	37,164	11,499	225	774	1,270,613

(*a*) Source : Water Conservation and Irrigation Commission. (*b*) Source : State Rivers and Water Supply Commission. (*c*) Included in Other Crops. (*d*) Includes Tobacco, 5,545 acres. (*e*) Includes lucerne for pasture.

(iii) *Research.* Comprehensive programmes of research and investigation are being pursued by State water and agricultural authorities and the Commonwealth Scientific and Industrial Research Organization, often in collaboration. Special attention is being given to the following :—high water tables due to the application of water ; surface accumulation of salt and other soil changes associated with irrigation ; methods of applying water efficiently ; increasing density of stock on irrigated pastures which leads to the spread of such diseases as foot rot and fluke in sheep, and mastitis and contagious abortion in cattle ; growth problems affecting plants and trees ; the prevention of evaporation from water storages ; and the potability of saline waters for stock.

The Commonwealth Scientific and Industrial Research Organization maintains the following research stations :—Merbein (Victoria)—horticultural problems, particularly of the dried vine fruits industry ; Griffith (New South Wales)—the influence of irrigation on plant life (using horticultural trees as test plants), irrigation methods, land drainage and soil structure ; Deniliquin (New South Wales)—pastures ; and the Kimberley Research Station (Western Australia)—tropical crops and pastures. In the maintenance of Merbein and Griffith Stations, the Commonwealth is assisted, financially and otherwise, by the New South Wales Water Conservation and Irrigation Commission, by the Dried Fruits Export Control Board and by private organizations.

The Soils Division of the Organization has made detailed surveys of more than a million acres since 1927, with less detailed reconnaissance surveys over many millions of acres. The Division works closely with State authorities. The keynote of soil investigations is relationship between soil and land use, and there is an increasing tendency to seek such surveys before irrigation districts are established. Research is also conducted in the field of water percolation in relation to soil structure.

The irrigation Research and Extension Committee plays an important part in the agricultural activity of the Murrumbidgee Irrigation Areas. It is representative of the State Department of Agriculture, the Commonwealth Scientific and Industrial Research Organization, the Rural Bank of New South Wales. the Soil Conservation Service of New South Wales and certain farmers' organizations (including Extension Groups). Finance is provided by these authorities on an agreed basis. The objectives are :—to enable the agricultural extension services to the farmers in the defined sub-region to be continued and developed ; to provide a system for advising on local agricultural policy and organization ; to provide means for farmer opinion to have due weight in the consideration of regional agricultural administration and policy ; to achieve a unified approach to sub-regional extension in all branches of agriculture ; to advise on the research needs of the sub-region and the co-ordination of the agricultural research of the various rural institutions working therein ; to achieve close liaison between research and extension ; and to conduct research in extension methods.

4. **Preservation of Catchments.**—Since water conservation commences on the catchments, it is becoming increasingly recognized that anything which interferes with catchment efficiency affects the quantity of water available for all purposes. Active steps are being taken to counteract soil erosion, to conserve soil generally, and to minimize the effects of floods, overstocking, bush fires, and the destruction of vegetative cover. All States and the Commonwealth have initiated forestry policies which provide for reafforestation and the preservation of catchments. In recent years, efforts to counteract soil erosion have been intensified and there is some evidence of a more unified approach to catchment, water, forestry, and land use factors regarded as parts of a single problem.

5. **Sub-surface Supplies.**—(i) *General.* While a more or less complete general picture of the available and potential surface water resources exists, much remains to be done with regard to the location and development of sub-surface supplies (artesian, sub-artesian and ground water), in view of their importance as the basis of settlement over large areas of Australia.

The extent of the artesian basins—particularly the Great Artesian Basin—has been fairly accurately determined, while the use of sub-artesian supplies is extensive and more development is possible. The shallower ground-water supplies, however, particularly along alluvium valleys and coastal sandbed areas, have not been investigated and developed in any degree, except in a few localities.

(ii) *Artesian and Sub-artesian Supplies.* Pressure water, variable in quantity and quality, either artesian or sub-artesian, is obtainable in many parts of Australia, the various artesian basins extending over approximately one-third of the continent. A map of Australia showing the extent of the known artesian basins appears on page 307 of this Year Book.

The Great Artesian Basin, the most extensive in the world, underlies an area of approximately 670,000 square miles, comprising about 430,000 in Queensland, 80,000 in New South Wales, 120,000 in South Australia and 40,000 in the Northern Territory. Of the numerous defined major and minor water-bearing basins in Australia, the following are the principal :—

PRINCIPAL WATER-BEARING BASINS : AUSTRALIA.

Name.	State.	Geological Age of Chief Aquifers.	Approximate Area.	Depth to Pressure Water.
			Square Miles.	Feet.
Great Artesian ..	Queensland, New South Wales, South Australia and Northern Territory	Pliocene-Permian ..	670,000	Up to 7,000
Murray ..	Victoria, New South Wales and South Australia	Miocene-Oligocene ..	107,000	100 to 900
Pirie-Torrens ..	South Australia..	Recent Pleistocene ..	4,000	Up to 600
South-west ..	Western Australia	Recent Jurassic ..	10,000	200 to 2,500
Adelaide ..	South Australia..	Recent Oligocene ..	1,100	10 to 850
East Gippsland ..	Victoria ..	Pleistocene-Oligocene	2,500	200 to 1,800
Eucla	Western Australia, South Australia	Pliocene-Miocene ..	68,000	300 to 2,000
North-west ..	Western Australia	Tertiary Permian ..	40,000	230 to 4,000
Desert and Fitzroy	Western Australia	Carnozoic-Palaeozoic	160,000	100 to 1,500
Barkly ..	Northern Territory, Queensland	Cretaceous, Cambrian and Upper Precambrian	57,000	150 to 1,000
Basins of Ord–Victoria Region	Northern Territory, Western Australia	Mainly Cambrian and Permian	Unknown	Unknown

More than 3,000 artesian bores have been constructed within the Great Artesian Basin and the daily free discharge from all bores continuing to flow in Australia has been stated to exceed 350 million gallons, of which the loss by evaporation and seepage has been estimated at more than 90 per cent. Sub-artesian bores and wells throughout Australia number more than 200,000.

Artesian water generally is good stock water, but it is unsuitable for plant life, while in certain areas sub-artesian waters are suitable for all uses including irrigation. In some districts a considerable amount of irrigation is carried out from shallow ground-water supplies.

In common with other countries possessing artesian supplies, Australia has been faced with the problem of flow diminution. It was recognized early that flows were diminishing as more bores were drilled, but it is now considered that while many of the bores will ultimately cease to flow, many will not cease, but will assume a perpetually steady rate of flow, corresponding with the average intake of water from rainfall absorbed by sandstone outcrops. Diminution in flows from artesian bores has emphasized the need to eliminate wastage as much as possible, and investigations have been made regarding wasteful methods of distribution of artesian water by open channels or " bore drains " and the careless use of water. (For greater detail on this subject *see* Official Year Book No. 37, pp. 1103–4.)

(iii) *Ground Water.* Ground water supplies are used in various parts of Australia for industry, irrigation, stock and domestic purposes. Two of the most important of these supplies are in New South Wales. The Hunter District Water Board pumps 10 million gallons per day for general use from the Tomago coastal sands near Newcastle and at Botany, Sydney, private industry pumps 5 million gallons per day for its own use from similar sands.

Recent exploration of the coastal sands north of the Tomago Sands has revealed a further potential production of 25 million gallons per day.

§ 3. National and Interstate Aspects.

1. **General.**—As the Commonwealth Constitution makes special reference to water problems, both the Federal and the State Governments have an interest in the control and conservation of water. The main responsibility for control of water resources resides in the individual State governments, but as political boundaries sometimes intersect river valleys and catchments, co-operation between governments has been necessary to develop resources in certain cases. Specific examples of Commonwealth–State and interstate co-operation and approach are given in the following sections.

In the Report on Irrigation, Water Conservation and Land Drainage presented to the Commonwealth Government by the Rural Reconstruction Commission in 1945, national aspects of water conservation and use were emphasized. The report recommended that to obviate lack of co-ordination, an all-Australian plan, having the assent of the various governments be adopted, and that the Commonwealth should endeavour to promote interstate co-operation and co-ordinated development generally.

In 1946, a conference between the Commonwealth and States agreed to revive the Irrigation Production Advisory Committee first established under the authority of the Australian Agricultural Council in 1938. Its functions are :—(*a*) to prepare for the consideration of the Australian Agricultural Council or any Committee of Ministers appointed by the Council, conclusions formed from investigations to be carried out by Commonwealth and State Officers into the various agricultural industries which it is possible to develop on irrigated lands ; (*b*) to undertake long-term co-ordination of land utilization in irrigable areas served by the River Murray and its tributaries, this involving co-ordination of all available lands and the carrying out of such supplementary investigations as may prove necessary.

2. **Murray River Scheme.**—(i) *General.* The Murray River and its tributaries form the largest river system in Australia. The catchment is approximately 414,000 square miles, or one-seventh of the area of the Australian continent, comprising five-sixths of New South Wales, over one-half of Victoria, one-sixth of Queensland and one-fortieth of South Australia. The Murray proper is 1,600 miles long. Its main tributaries are the Murrumbidgee (980 miles), the Darling (1,700 miles), and the Goulburn (280 miles). The average annual flow of each of the chief contributory streams is as follows :—Upper Murray, including the Mitta Mitta and Kiewa Rivers, 3,506,000 acre feet ; Murrumbidgee River, 2,280,000 acre feet ; Goulburn River (including Broken River), 2,502,000 acre feet ; Darling River, 2,224,000 acre feet ; and Ovens River, 1,169,000 acre feet. Irrigated production in the River Murray basin is mainly in the form of wine, dried fruits, fresh fruits, rice, vegetables, dairy produce, wool, fat lambs, poultry, eggs and pigs.

For a brief summary of the historical events leading up to the River Murray Agreement (1915) by the Governments of the Commonwealth, New South Wales, Victoria, and South Australia, *see* issues of the Year Book prior to No. 39. The Agreement provided for the construction of works, the allocation of the water between the three States, and the appointment of a Commission to implement the Agreement. The Commission comprises four Commissioners, representing the Commonwealth and the three States respectively. The Commonwealth representative presides.

(ii) *River Murray Waters Agreement.* Under the Agreement, construction works are carried out by the States (who are also responsible for maintenance) subject to the approval and direction of the Commission. The Agreement provides that the minimum quantity of water to be allowed to pass for supply to South Australia in each year shall be sufficient to fill Lake Victoria storage once, and with the aid of water returned from Lake Victoria, to maintain certain specified flows in the lower river varying from 47,000 acre feet per month in the winter months to 134,000 acre feet per month in the four summer months of maximum demand—the total amounting to 1,254.000 acre feet over twelve months. These flows are to meet domestic and stock requirements in South Australia, losses of water in lockages and evaporation losses other than in the lakes at the Murray mouth, together with 603,000 acre feet per annum for diversion from the Murray for irrigation in South Australia. The flow at Albury is shared equally by New South Wales and Victoria, and each of these States has full control of its tributaries below Albury, subject in each case to the fulfilment of the South Australian allocation. For a brief outline of the operation of the Agreement prior to 1949 *see* Official Year Book No. 40 (p. 1065) and earlier issues.

At a Conference of Ministers held in July, 1949, to consider the diversion of the Snowy River, it was decided that, by diversion of streams in the Snowy Mountains area, an average of approximately 400,000 acre feet per annum would be added to the Murray River (*see* para. 4, Snowy Mountains Hydro-electric Scheme, page 297) and that a storage of not less than 1,500,000 acre feet should be provided in order to give additional regulation of the Murray River itself as well as to provide for regulation of the diverted waters. Hydro-electric potentialities would also affect the size of the storage.

The River Murray Commission investigated the position and found that an increase in capacity of 500,000 acre feet in storage on the Upper Murray River above Albury was the maximum that was economically justifiable for the regulation for irrigation purposes of the waters of the Upper Murray River and of waters added from the Snowy River. The Commission agreed that this increase could best be provided by increasing the size of the Hume Reservoir from its previously designed capacity of 2,000,000 acre feet to 2,500,000 acre feet, but if for hydro-electric purposes additional storages become justified in the future further increases would best be provided at some other site. It subsequently recommended to the contracting Governments that the River Murray Waters Agreement be amended to provide for this enlargement of the Hume Reservoir to 2,500,000 acre feet. A conference of Ministers considered the recommendation in July, 1954 and agreed to the enlargement. In addition, it was agreed that the Commission should be given power to construct regulators to carry out such other work on the River Murray between Tocumwal and Echuca as it considered necessary to reduce the losses from the regulated flow in that stretch of the river. The amended Agreement was ratified in the Parliaments of the Commonwealth and the three States and was proclaimed on 7th April, 1955.

The total estimated quantity of water diverted from the Murray and its tributaries (under the River Murray Agreement in 1955–56 for irrigation and other purposes, including impounding in dams, was as follows (in acre feet) :—New South Wales, 1,008,000 ; Victoria, 3,108,000 ; South Australia, 190,500 ; a total of 4,306,500 acre feet.

(iii) *River Murray Works.* One of the major works of the Murray River Scheme is the Hume Reservoir, situated just below the junction of the Murray and Mitta Mitta Rivers, 10 miles above Albury, forming a lake of 33,000 acres. The design comprises a mass concrete spillway and outlet works extending 1,000 feet and an earthen embankment 110 feet high extending for 4,000 feet across the river flats. The length of the total structure is approximately one mile. Work is now in progress on the installation of a hydro-electric generating station below the dam and also on the completion of the reservoir to its recently approved capacity of 2,500,000 acre feet.

The Yarrawonga Diversion Weir was completed in 1939 to raise the river level so that water could be diverted by gravitation into main channels constructed on either side of the river. Between the Yarrawonga Weir and the Murray mouth, thirteen weirs and locks have been built. Two flood diversion weirs have been constructed on the Murrumbidgee—one between Hay and the Lachlan Junction and the other below the Lachlan Junction.

The Mulwala Canal, served by the Yarrawonga Weir, has an off-take capacity of 2,500 cubic feet per second, and will serve 1,500,000 acres of land in New South Wales. The Yarrawonga Channel, on the Victorian side, has an off-take capacity of 1,250 cubic feet per second, and is designed to serve 270,000 acres. Only a portion of both these areas will be irrigated.

Adjoining the river in New South Wales and 35 miles from the Murray-Darling Junction, Lake Victoria storage, with a capacity of 551,700 acre feet and a surface area of 27,670 acres, was completed in 1928. The water released from Lake Victoria is used by the South Australian settlements. Work is proceeding on the enlargement of the inlet channel to Lake Victoria to permit greater diversion of periodical flood flows of short duration.

Five barrages across channels near the Murray River mouth connecting Lake Alexandrina with the sea were completed in 1940 to prevent ingress of salt water to Lakes Alexandrina and Albert and to the lower river, thereby increasing the productivity of adjacent lands. The structures maintain a sufficiently high level for 50 miles up river to permit watering by gravitation of a considerable area of reclaimed river flats. The total distance across the barrages and intervening islands is 15 miles.

In addition to the works carried out under the auspices of the Commission, the separate States have constructed thousands of miles of distribution channels and have provided a number of storages on the tributaries, thereby contributing very materially to the large amount of irrigation development in the Murray Basin. The total capacities of such main storages are : New South Wales—Burrinjuck (Murrumbidgee), 837,000 acre feet ; Wyangala (Lachlan), 303,900 acre feet ; Victoria—Eildon (Goulburn), 2,750,000 acre feet ; Waranga (Goulburn), 333,400 acre feet. More details of these and other State works on Murray tributaries will be found in the sections dealing with State systems. No storages exist on the Murray in South Australia.

3. **New South Wales-Queensland Border Rivers Agreement.**—The New South Wales-Queensland Border Rivers Agreement came into effect on 1st July, 1947. The Agreement provides for the construction of certain works on parts of those portions of the Severn, Dumaresq, Macintyre and Barwon Rivers which constitute part of the boundary between New South Wales and Queensland, for the furtherance of water conservation, water supply and irrigation in those States.

The works to be constructed comprise a dam on the Dumaresq River at a site to be selected by the Commission to give a storage basin with a capacity as large as is reasonably practicable and not less than six nor more than twelve weirs as may be found necessary to meet the requirements of irrigation along the rivers. Provision is also made for the construction of not more than four regulators in the effluents from the barrier rivers and for the taking over of the existing weir in the Macintyre River at Goondiwindi and the existing weir in the Barwon River at Mungindi. The costs of these works and of administration are to be borne by the States in equal shares. The agreement further provides that the water discharged from the Dumaresq storage, whether by regulated or unregulated flow, shall be available to the two States in equal shares.

The Water Conservation and Irrigation Commission of New South Wales, which is the constructing authority for the dam, has for some time past been carrying out investigations of alternate dam sites on the Dumaresq River near Mingoola Station Homestead which is approximately 39 miles from Tenterfield. Foundation drilling supplemented by a geophysical survey carried out by the Commonwealth Bureau of Mineral Resources disclosed unfavourable foundation conditions at all sites, the depth of alluvium overlying sound rock exceeding 150 feet in all cases. In an endeavour to obtain more economical storages, investigations have now been extended to tributary streams and superficially suitable sites have been located on Pike's Creek and the Mole River. A geophysical survey has recently been made at each of these sites and comparative estimates are in course of preparation to determine the relative economy of providing one large storage at Mingoola or two smaller storages on the tributaries.

The Irrigation and Water Supply Commission of Queensland, which is the constructing authority for the new weirs and regulators, has carried out detailed investigations as to sites for such works. The construction of Bonshaw and Cunningham Weirs on the Dumaresq River was completed in January, 1953 and June, 1954 respectively.

Investigations are proceeding and designs are being prepared for a weir and regulator on the Barwon River at the offtake of the Boomi River and for a low level weir to establish a pumping pool at a location 35.3 miles on the Dumaresq River. The existing Goondiwindi and Mungindi Weirs are being maintained, operated and controlled by the Queensland Irrigation and Water Supply Commission.

The catchments for the border streams (2,000 square miles) extend to the granite areas in the vicinity of Tenterfield (New South Wales) and Stanthorpe (Queensland) and elevation rises to 3,000 feet. Average rainfall is 30 inches. The catchments and the areas suitable for irrigation are approximately equal in each State. Climatic conditions are such that it is necessary to supplement rainfall from April to October by irrigation to stabilize and increase production. The capacity of the area to grow lucerne and tobacco under irrigation has already been demonstrated. Irrigation of cotton, root crops, cereals, and citrus fruit, and expansion of the fat stock industry, is being examined.

4. **Snowy Mountains Hydro-electric Scheme.***—(i) *General.* Following a comprehensive investigation into both the water and power potential of the Snowy River waters by a Technical Committee representative of the Commonwealth and the States of New South Wales and Victoria in 1947 and 1948, and the submission by the committee of reports in 1948 and 1949, the Commonwealth Parliament in July, 1949 passed the Snowy Mountains Hydro-electric Power Act setting up an Authority to implement the proposals agreed upon.

The basis of the proposals is to impound the Snowy River waters at high elevations and, by diverting them into tunnels passing under the Alps, to use their potential power for the generation of electricity and then to discharge them into the Murray and Murrumbidgee River systems for use in the irrigation areas.

The scheme will be constructed in two parts, the first being known as the Snowy-Murray Development where the water is to be diverted by tunnel from a large dam across the Snowy River at Jindabyne to the Swampy Plains River in the Murray Valley ; and the second as the Tumut Development, in which water will be diverted by tunnel from a dam at Adaminaby on the Eucumbene River, a tributary of the Snowy, to the Tumut River, a tributary of the Murrumbidgee. The whole scheme will involve the construction of seven major dams (with a total storage capacity of approximately 7 million acre feet), fifteen power stations, more than 80 miles of large diameter tunnels, and over 330 miles of racelines at high elevations.

Latest estimates indicate that the total cost will be approximately £419 million. The scheme is the greatest engineering and developmental work ever undertaken in Australia and one of the major engineering projects of the world.

(ii) *Snowy Mountains Hydro-electric Power Act* 1949. The Snowy Mountains Hydro-electric Authority is constituted by a Commissioner, who is assisted by two Associate Commissioners. The functions of the Authority are defined in the Act as follows :—(*a*) to generate electricity by means of hydro-electric works in the Snowy Mountains area and (*b*) to supply electricity so generated to the Commonwealth for defence purposes and for consumption in the Australian Capital Territory. The general powers of the Authority as defined in the Act are as follows :—For the purpose of performing its functions the Authority shall have power to construct, maintain, operate, protect, manage and control works—(*a*) for the collection, diversion and storage of water in the Snowy Mountains Area ; (*b*) for the generation of electricity in that area ; (*c*) for the transmission of electricity generated by the Authority ; and (*d*) incidental or related to the construction, maintenance, operation, protection, management or control of any of the works specified above. The Act provides that the Authority may sell to a State, or to an authority of a State, electricity generated by the Authority which is not immediately required by the Commonwealth for defence purposes or for consumption in the Australian Capital Territory.

* *See also* Chapter VIII.—Electric Power Generation and Distribution, p. 266. For more detailed information *see* special article by the Commissioner, Snowy Mountains Hydro-electric Authority (Sir William Hudson) which appeared in Chapter XXIX.—Miscellaneous, of Official Year Book No. 42.

(iii) *The Authority's Objectives and Programme.* The two basic objectives are the production of electricity and the diversion of water inland.

The first power station, at Guthega, came into service in April, 1955. Additional generating capacity is scheduled to become available progressively.

By the end of 1959, the Snowy Scheme will supply the Murrumbidgee River with approximately 530,000 acre feet per annum of additional water, by diversions from the Eucumbene and the Upper Tooma Rivers. Ultimately the scheme will provide approximately 1,818,000 acre feet per annum of additional regulated water of which 1,020,000 acre feet will go to the Murrumbidgee and 798,000 acre feet per annum to the Murray.

The New South Wales Department of Public Works, on behalf of the Authority, is supervising the construction of the Adaminaby Dam, for which a contract was let in May, 1956. The Department of Main Roads and the Snowy River Shire are reconstructing over 90 miles of existing roads. Construction is now in progress on the 14 mile Eucumbene–Tumut Tunnel, Tumut Pond Dam, the 8,000 feet pressure tunnel leading to Station T1, and on Station T1 itself. Designs are in progress for the Tooma-Tumut Diversion, tenders for the construction of which will be called about the end of 1956, and also for the T2 Project, construction of which will commence about one year later.

B. STATES AND TERRITORIES.

§ 1. Australian Local Pattern of Water Conservation and Use.

The foregoing sections deal with water conservation and irrigation in Australia generally and with national and interstate projects. The following survey indicates the local pattern of water resources and the steps taken by the State Governments to bring about their development. It will be seen that water policies in the various States tend to assume a distinctive and characteristic pattern closely allied with climatic conditions and specific local needs.

In Victoria, almost every form of water scheme is in operation. In New South Wales, major emphasis at present is on irrigation and stock development in the dry areas along the Murray and Murrumbidgee Rivers, though a substantial scheme of intensive irrigation is being conducted in the Murrumbidgee Irrigation Areas. In Queensland, up to the present, the predominant emphasis has fallen on water (mainly underground sources) for the stock industries, and the development of small irrigation schemes in sub-humid and humid areas, especially to stabilize sugar production.

Apart from regular irrigation practices along the Murray River, South Australian authorities are vitally concerned with reticulated supplies for rural areas and towns. Western Australia has developed unique rock catchments and piped supplies for agricultural areas and towns in dry districts. Tasmanian interest appertains to hydro-electric generation almost exclusively. The Northern Territory is primarily concerned with stock supplies and the safeguarding of long stock routes.

§ 2. New South Wales.

1. **General.**—(i) *Rainfall and History.* In issue No. 37 of this publication (p. 1110) information on the pattern of rainfall and the history of irrigation in New South Wales preceded the description of water conservation and use in that State, but it has now been omitted. (*See also* Chapter II.—Physiography, p. 45 of this issue.)

(ii) *Administration.* The Water Conservation and Irrigation Commission of New South Wales consists of three members appointed by the Governor. The operations of the Commission cover water conservation, control of irrigation areas, establishment, operation and maintenance of works for domestic and stock water supply, irrigation districts, flood control districts, sub-soil drainage districts, constitution of water trusts, the issue of licences for private irrigation, artesian and shallow boring, assistance under the provisions of the farm water supplies scheme and river improvement works.

Under the Water Act, the right to the use and flow, and the control of water in all rivers and lakes which flow through, or past, or are situated within, the land of two or more occupiers, is vested in the Commission for the benefit of the Crown. A system of licences operates for the protection of private works of water conservation, irrigation, water supply, drainage, and prevention of inundation.

For particulars of the New South Wales–Queensland Border Rivers Agreement ratified by Acts of both States in 1947, *see* page 296 of this Chapter.

2. **Schemes Summarized.**—(i) *Location and Type.* The bulk of irrigated land is along the Murray and its tributary the Murrumbidgee. Smaller areas are served by the Wyangala Dam and Lake Brewster on the Lachlan, a tributary of the Murrumbidgee. None of the other rivers is regulated by large head storages, though weirs and dams have been provided for town supplies, etc., in many places, and head storages have been commenced on the Macquarie, Namoi and Hunter Rivers. Substantial use is made of artesian and sub-artesian water in pastoral areas.

New South Wales legislation provides for the constitution and control of various schemes having different characteristics and including Irrigation Areas, Irrigation Districts, Water Trust Districts, Flood Control and Irrigation Districts and River Improvement Districts. There are five Irrigation Areas :—The Murrumbidgee Irrigation Areas consisting of 450,305 acres served with water through a channel system stemming from the river at Berembed Weir ; the Coomealla Irrigation Area of 35,062 acres, served by pumping from the Murray ; the Curlwaa Irrigation Area of 10,209 acres, supplied from the Murray by pumping ; the Hay Irrigation Area of 6,806 acres, supplied with water pumped from the Murrumbidgee ; and the Tullakool Irrigation Area of 16,305 acres supplied from the Edward River at Stevens Weir. All these areas are administered by the Commission, and details of the various schemes are given in sub-section (iii) below.

(ii) *Works.* The capacities of the main storages (in acre feet) are :—

Murray :—Half share of Hume Reservoir, weirs and locks to Wentworth (802,420) ; Stevens Weir, Edward River (7,165).

Murrumbidgee :—Burrinjuck Dam (837,000) ; Berembed Weir (10,000) ; Redbank Weir (7,360) ; Maude Weir (6,740).

Lachlan :—Wyangala Dam (303,900) ; Lake Brewster (123,900) ; Lake Cargelligo (29,435) ; Jemalong Weir (2,200).

Water from the Hume Reservoir is used for domestic and stock purposes, to provide bulk supplies for country towns, for the irrigation of vines, fruits and fodder in the Curlwaa and Coomealla areas, for rice and other cereals and for pastures in the Tullakool Irrigation Area, for domestic and stock supply and irrigation in the Berriquin, Wakool and Denimein Districts, and for water trusts for domestic and stock purposes and/or irrigation.

The Wyangala Dam is 30 miles upstream from Cowra in the Central West. It has a catchment of 3,200 square miles. Water from the dam, supplemented by the unregulated flow of the Belubula River, provides for domestic and stock purposes along the full length of the river (over 700 miles) and also for irrigation by land holders operating licensed pumps. The towns of Cowra, Forbes, Condobolin, Hillston and Booligal are supplied. Balance storages at Lake Cargelligo and at Lake Brewster conserve water during periods of high flow for release as required. Water from the Lachlan, diverted at Jemalong Weir, supplied the districts of Jemalong and Wylde's Plains, serving an area of 224,556 acres. Wyangala is now producing hydro-electric power. Proposals for future development include provision of a head storage on the Belubula River.

The approximate total length of channels (including main canals) in New South Wales is 2,890 miles. The approximate length of drains and escape channels is 983 miles, and the approximate total length of pipe lines is 68 miles, making a grand total of 3,941 miles of channels and pipe lines, etc.

(iii) *Extent of Systems and Nature of Irrigated Culture.* The following table shows the areas of the various irrigation systems and particulars of the areas under irrigated culture in New South Wales during 1955–56.

AREAS OF SYSTEMS AND OF LAND UNDER IRRIGATED CULTURE: NEW SOUTH WALES, 1955-56.

(Acres.)

System, etc.	Total Area.	Area under Irrigated Culture.										
		Rice.	Other Cereals Grown for Grain.	Lucerne. (a)	Other Fodder Crops.	Pastures.		Vineyards.	Orchards. (c)	Vegetables.	Fallow Land and Miscellaneous.	Total.
						Sown. (b)	Natural.					
Irrigation Areas—												
Murrumbidgee (within the Areas) ..	450,305	24,970	1,381	2,392	827	22,621	1,799	5,309	12,306	3,054	5,623	80,282
Lands adjacent supplied under agreement	(d)	117	600	82	2	370	10	3	81	13	..	1,278
Coomealla	35,062	..	..	14	..	..	..	3,998	774	38	..	4,824
Curlwaa	10,209	..	..	26	70	..	..	616	1,068	2	..	1,782
Hay	6,806	..	..	54	..	1,010	8	..	..	..	3	1,075
Tullakool	16,305	1,565	230	75	160	3,953	..	..	..	..	490	6,473
Total	*e 518,687*	*26,652*	*2,211*	*2,643*	*1,059*	*27,954*	*1,817*	*9,926*	*14,229*	*3,107*	*6,116*	*95,714*
Irrigation Districts—												
Benerembah ..	108,531	4,433	1,177	1,100	145	5,832	100	..	..	..	670	13,457
Tabbita	10,745	361	..	80	..	188	200	..	..	..	30	859
Wah Wah	570,470	..	130	720	290	546	..	..	..	..	370	2,056
Berriquin	779,564	..	1,283	29,810	..	118,176	531	..	..	10	1,298	151,108
Wakool	495,430	7,456	350	1,580	620	42,280	850	..	..	8	200	53,344
Denimein	147,005	2,035	130	893	80	2,394	800	..	12	..	..	6,344
Jemalong and Wylde's Plains	224,556	900	342	3,781	195	450	275	..	..	..	..	5,043
Gumly	345	..	28	63	..	..	33	..	18	37	..	179
Deniboota(f) ..	306,907	..	150	..	310	1,041	100	..	..	..	..	2,501
Total	*2,643,553*	*15,185*	*3,590*	*38,027*	*1,640*	*170,907*	*2,889*	..	*30*	*55*	*2,568*	*234,891*
Flood Control Districts—												
Lowbidgee	375,000	..	..	..	..	..	(g)94,118	..	..	..	..	(g)94,118
Medgun	272,800	..	..	..	..	..	(g)61,760	..	..	..	..	(g)61,760
Total	*647,800*	..	..	..	..	..	*g 155,878*	..	..	..	..	*g 155,878*
Irrigation Trusts—												
Pomona	1,580	..	..	..	..	..	..	770	130	..	..	900
Blairmore	315	..	..	..	..	..	..	..	..	..	..	(d)
Bringan	4,933	..	..	..	..	..	..	..	..	..	..	(d)
Bungunyah-Koraleigh	1,810	..	..	..	20	..	..	1,060	72	60	..	1,212
Glenview	661	..	..	62	..	..	336	..	71	..	..	469
Goodnight	1,167	..	..	..	..	..	..	564	41	..	..	605
Bama	3,446	..	..	..	..	..	..	..	..	..	..	(d)
Total	*13,912*	..	..	*62*	*20*	..	*336*	*2,394*	*314*	*60*	..	(e) *3,186*
Water Trusts—Domestic and stock supplies ..	*2,914,831*	..	..	..	..	..	..	..	..	..	..	..
Licensed Diversions(h)—												
To irrigate	(d)	..	..	*8,625*	*3,119*	*12,679*	*3,389*	*640*	*3,569*	*13,436*	(i) *363*	*45,820*
Grand Total(e) ..	(d)	41,837	5,801	49,357	5,838	211,540	164,309	12,960	18,142	16,658	9,047	*j* 535,489

(a) Includes grazing and cutting. (b) Perennial and annual self-seeding. Perennial amounted to 18,238 acres. (c) Citrus and deciduous. Deciduous amounted to 7,308 acres of which 6,704 acres were in the Murrumbidgee Irrigation Area. (d) Not available. (e) Incomplete. (f) Works incomplete. (g) Area irrigable; details of area actually irrigated are not available. (h) Excludes domestic and stock supplies for which particulars are not available. (i) Tobacco. (j) Includes Flood Control Districts; but excludes some Irrigation Trusts for which information is not available.

3. **Murrumbidgee Irrigation Areas.**—(i) *Description.* These areas comprise about a third of the State's irrigated acreage and in 1955–56, together with lands adjacent supplied under agreement, received 195,468 acre feet of the total water allocated within the State for stock, domestic supply and irrigation (625,067 acre feet). They are served by the Burrinjuck Dam (capacity 837,000 acre feet), 40 miles north-west of Canberra, on the Murrumbidgee. The catchment above the dam is 5,000 square miles. The river rises on the high plateau north of Mount Kosciusko where the average annual rainfall exceeds 60 inches. Flow for the irrigation districts is supplemented by unregulated flow below the dam from the Tumut River. The dam also provides town supplies for Gundagai, Wagga, Narrandera, Hay, Balranald, and for towns served by the South-West Tablelands scheme.

Domestic and stock water and water for irrigation are supplied for the Irrigation Districts of Tabbita, Benerembah and Wah Wah and the Flood Control and Irrigation District of Lowbidgee. Flood flows are relied on to serve the Lowbidgee district and water is not released from the dam for that purpose. For the other undertakings, however, water is stored during the winter and spring freshets, fed by melting snows, and is released during the September-April irrigation season. It passes along the river channel to Berembed Weir, 240 miles westward, where it is diverted to the main canal with an off-take capacity of 1,600 cubic feet per second. The main canal has been completed to beyond Griffith, 96½ miles from the off-take. Reticulation channels aggregate approximately 834 miles and drainage channels 765 miles. In addition, approximately 374 miles of supply channels run through adjacent irrigation districts in which the water supply is operated and maintained by the Commission, but land transactions are not under its control.

The land on which the Murrumbidgee Irrigation Areas are situated originally comprised large sheep stations and was sparsely populated. Population was 12,000 in 1923, 15,000 in 1929, 20,000 at the 1947 Census and 24,000 at the 1954 Census. At the 1954 Census the population of the Yanco district (with Leeton as the centre) was 10,000 ; and the population of the Mirrool Area (with Griffith as the centre) was 14,000.

(ii) *Administration.* The Water Conservation and Irrigation Commission controls land transactions and water supplies for the Murrumbidgee Irrigation Areas, also the distribution of electricity throughout those areas. Other local government services, including town water supply, are provided by Shire Councils. Land is disposed of by the Commission under freehold or perpetual lease tenure or leased for short terms for grazing or cultivation. The area under occupation at 30th June, 1956, was 350,811 acres, including 35,445 held for short lease grazing, agriculture, etc.

(iii) *Production.* Since the inauguration of the scheme in 1911 the volume of production from the area has greatly increased. Numbers of new crops are grown while the volume of the major products of the area prior to the scheme, such as wool and livestock for slaughtering, has expanded considerably. The principal products to-day are : wool, livestock for slaughtering, rice, citrus fruits, peaches and nectarines, grapes, tomatoes, peas, beans and root vegetables.

Rice growing was initiated on the Murrumbidgee Irrigation Area in 1924 and has since become the most important crop grown in the area. In 1955–56, the total area sown in the Murrumbidgee Irrigation Area (and adjacent lands supplied under agreement) was 25,087 acres and the total quantity of water delivered for the rice crops was 122,428 acre feet.

In a normal season, the water supplied for rice represents about one-half of the total delivered on the Murrumbidgee Irrigation Area although in the 1955–56 season the proportion was considerably greater.

Co-operation is a prominent feature in the Murrumbidgee Areas. Co-operative organizations in the Mirrool section handle about 300,000 bushels of fruit per year (compared with 54,600 in 1927–28). The annual sales turnover of the Leeton cannery in recent years has been approximately £2,000,000. Settlers and government agencies co-operate extensively in all matters relating to irrigation practice.

4. **Other Irrigation Areas.**—The Curlwaa, Coomealla, Hay and Tullakool Irrigation Areas follow the same administrative pattern as the Murrumbidgee Areas—that is, land transactions are administered by the Water Conservation and Irrigation Commission which also is responsible for the operation and maintenance of works to supply water at rates determined by the Commission.

Curlwaa Area, on the Murray near Wentworth, consists of 10,209 acres of which 8,372 acres were occupied at 30th June, 1956. Production consists of dried vine fruits, deciduous fruits and fodder crops.

Coomealla Area, 9 miles upstream from Curlwaa, comprises 35,062 acres of which 31,353 acres were occupied at 30th June, 1956. Production consists of vine and citrus fruits. An extension of the Coomealla Irrigation Area has been completed in recent years to provide irrigation farms for ex-servicemen and 100 ex-servicemen have been placed on the new farms.

Tullakool Area, formerly part of the Wakool Irrigation District, comprises 16,305 acres of which 15,808 acres are occupied. Production consists of fat lambs, wheat and rice.

Hay Area, on the lower Murrumbidgee, consists of 6,806 acres, of which, 6,240 acres are occupied. Production comprises dairy products, fat lambs, sheep, wool and fodders.

5. **Irrigation Districts.**—These Districts are set up under the Water Act for (*a*) domestic and stock water supply and (*b*) irrigation. They differ from water trusts in that the cost of the works is not required to be repaid over a period, but annual charges are made by the State for water supplied to landholders. The following are the districts or provisional districts constituted and the areas of land benefited :—*Murray River*—Wakool District (completed) 495,430 acres, Berriquin Provisional District (completed) 779,564 acres, Deniboota Provisional District (first section completed) 306,907 acres, Denimein Provisional District (completed) 147,005 acres, Jernargo Provisional District (certain portions of which have been included in Berriquin District) 4,505 acres, Barramein Provisional District (domestic and stock supply only—works not yet commenced) 88,651 acres ; *Murrumbidgee River* (completed)—Benerembah District 108,531 acres, Tabbita District 10,745 acres, Wah Wah Provisional District 570,470 acres, Gumly Provisional District 345 acres ; *Lachlan River* (completed)—Jemalong and Wylde's Plains District 224,556 acres.

Since the completion of the Hume Reservoir, several such districts have been established along the Murray to utilize the New South Wales share of the storage. Water is not available for the whole of the 5,000,000 acres adjacent to the Murray in New South Wales, and therefore the schemes are based on " extensive " irrigation—that is, water rights are allotted to holdings on the basis that only a portion of each holding (one acre in three, five or ten, according to the district, etc.) will be irrigated, but additional water, when available, may be obtained by landholders. " Water right " means right to such a quantity annually of water, 12 inches deep, as will cover an area of one acre.

Water to serve Berriquin and Wakool Districts is diverted through a main canal which will be 100 miles long when completed. At 30th June, 1956, the total length of completed canal and channels was 851 miles, including Mulwala Canal 75 miles, Berrigan channel 22 miles, subsidiary channels 712 miles, escape channels 33 miles and cross drainage channels 9 miles. Off-take capacity of the Mulwala Canal is 5,000 acre feet per day. Ultimately the water will serve Deniboota and other districts for which works have yet to be completed.

Wakool, with 384 miles of channel, contains 292 holdings and it is expected that the area developed by irrigation will comprise about one acre in 10 of the total area. The total area irrigated in 1955–56 was 53,344 acres and water supplied was 61,428 acre feet. Crops comprised fodders, pastures, rice, cereals and vegetables, but sheep raising is the main industry.

Considerable subdivision has occurred within the Berriquin District and the proportion of the total area developed for irrigation is higher than in the case of Wakool. Total irrigated acreage was 151,108 at 30th June, 1956. Sheep and wheat growing are the main industries. The fat lamb industry is well developed and expanding. Dairying is making headway, and a butter factory has been established at Finley.

In the Benerembah, Tabbita and Wah Wah Districts, supplied from the channels of the Murrumbidgee Irrigation Areas, the quantity of water supplied during the 1955–56 season for irrigation, etc. was 48,907 acre feet, and the area irrigated was 16,372 acres, including rice and other cereals, pastures, and fodder crops.

For the same season, 3,502 acre feet of water were supplied from the Lachlan River to irrigate a total area of 5,043 acres within the Jemalong and Wylde's Plains Districts.

In 1955–56, which was a year of abnormally heavy rainfall, the areas irrigated and the quantity of water supplied were considerably lower than those for normal seasons in recent years.

6. **Water Trust Districts, Irrigation Trusts and Flood Control and Irrigation Districts.**—The Water Act provides for the constitution of Trust Districts for domestic and stock water and irrigation and empowers the Commission to construct, acquire or utilize necessary works. When the works are completed, they are handed over to trustees to administer.

The trustees are elected by the occupiers of the land and act with a representative of the Commission. They are empowered to levy and collect rates covering the cost of the works repayable to the Crown by instalments and also the cost of operation and maintenance of the works. The rates are struck according to the area of land which benefits. The following water trusts—other than irrigation—have been constituted (the area in acres of each district is shown in parentheses)—*Murray River*—Tuppal Creek (78,080), Bullatale Creek (68,320), Little Merran Creek (157,440), Poon Boon (32,980), Minnie Bend Flood Prevention (2,190) ; *Murrumbidgee River*—Yanco, Colombo and Billabong Creeks (1,001,210) ; *Lachlan River*—Torriganny, Muggabah and Merrimajeel Creeks (170,240) Condobolin West Weir (4,480), Marrowie Creek (292,640), Ulonga (71,655), Micabil Weir (11,500) ; *Miscellaneous*—Algudgerie Creek (9,760), Nidgery Weir (46,880), Great Ana Branch of Darling River (967,339), Collarenebri town water supply (117)—making in all a total area of 2,914,831 acres. Thirteen of these trusts have been formed for the provision of water for domestic and stock purposes, one for a town supply and one for flood prevention.

Irrigation Trusts are established under the same Act and are administered by trustees in a similar way. The following are the Trust Districts (area in acres is shown in parentheses) :—*Hunter River*—Blairmore (315) ; *Murray River*—Bama (3,446), Goodnight (1,167), Bungunyak-Koraleigh (1,810), Glenview (661), Bringan (4,933) ; *Darling River*—Pomona (1,580)—making in all a total area of 13,912 acres.

The Lowbidgee Provisional Flood Control and Irrigation District (375,000 acres), the first of its kind, was constituted in 1945. Its purpose is to provide flood irrigation for pasture lands on the lower Murrumbidgee by water diverted from the Maude and Redbank Weirs. There are 48 holdings. Another district, Medgun (272,800 acres) near Moree in the North-West is also in operation. There are 20 holdings in the district and the area benefited by controlled floodings is approximately 61,800 acres.

7. **River and Lake, and Farm Water Supplies.**—During recent years, the numbers of licences and permits issued to individuals to draw water from rivers and lakes for irrigation have increased substantially, especially along the coastal streams in sub-humid districts where the value of supplementary irrigation is becoming more recognized as a means of stabilizing production in lean months. There has also been a considerable increase along the Murrumbidgee and Lachlan.

The Farm Water Supplies Act was passed in 1946. Technical advice and assistance, and also financial assistance, are made available to aid individual farmers and groups of farmers to provide and improve water supplies for domestic, stock and irrigation purposes by means of wells, bores, excavated tanks, weirs or dams.

8. **Underground Water.**—Extensive use is made of artesian, sub-artesian, and shallow underground water. Fractured palaeozoic rocks in the South-east corner of the State provided useful supplies of ground water usually at depths of 50–250 feet. Eighty thousand square miles in the northern and western portions are covered by the Great Artesian Basin. Eighty-one Bore Water Trusts and twelve Artesian Wells Districts have been constituted. The Bore Trusts are administered in the same way as Water Trusts, but in Artesian Wells Districts settlers maintain the drains. Bore Trusts and Artesian Districts cover about 5 million acres and water is distributed through 3,368 miles of open earth drains. The number of artesian bores giving a flowing or pumping supply at 30th June, 1956, was 1,031 and the estimated total daily flow from 586 flowing bores was 60 million gallons. The estimated flow in 1914–15 was 99 million gallons per day for 372 bores. The deepest bore is Boronga No. 2 (4,570 feet), which also has the greatest flow, namely 1,115,000 gallons per day. Of the total number of bores sunk, 234 have been installed by the Government in connexion with public watering places, Bore Water Trusts or Artesian Wells Districts.

Since 1912, the Government has assisted settlers in shallow boring operations for which repayments are required over a period. To 30th June, 1956, the total constructed by the Commission's plants was 4,591 and their average depth was 304 feet.

9. **Future Programme.**—The programme of post-war development already in hand includes the provision of eighteen dams and storages, eight diversion weirs, and flood mitigation and river protection works in various parts of the State. Construction has been commenced on head storages at Keepit on the Namoi, Glenbawn on the Hunter and Burrendong on the Macquarie, while legislation has been passed authorizing the construction of a flood control dam at Warkworth in the Hunter Valley and a storage dam at Blowering on the Tumut River. In the case of Burrendong Dam, work has been

temporarily suspended in order to enable the Water Conservation and Irrigation Commission to concentrate its available resources on the speedy completion of works having higher priority. The Menindee Lakes storage project—part of the scheme for conserving the waters of the Darling River has been commenced, but as in the case of Burrendong Dam, work has been temporarily suspended. The Hunter River development concerns an exceptionally fertile coastal valley, forming the hinterland to Newcastle, where the annual rainfall is not heavy and variations from month to month are considerable. This is the first coastal scheme initiated in New South Wales. The total estimated capacity of all proposed new storages is 5,500,000 acre feet.

10. **Hydro-electricity.**—A survey of the use of water for power generation in New South Wales may be found in the previous chapter (*see* page 271).

§ 3. Victoria.

1. **General.**—(i) *Rainfall.* Particulars of the rainfall pattern of Victoria were given on page 1117 of Official Year Book No. 37. (*See also* Chapter II.—Physiography, p. 45 of this issue.)

(ii) *Administration.* The passage of the Irrigation Act of 1886 put the control of surface waters under the Crown, provided for the establishment of Irrigation Trusts and marked the beginning of irrigation development. In 1905, the Water Act established the State Rivers and Water Supply Commission and gave it control of all irrigation, rural domestic and stock supplies, town water supplies and flood protection and drainage undertakings outside the Metropolitan area, with the exception of the irrigation area operated by the First Mildura Irrigation Trust and the town water supplies operated by locally constituted Waterworks Trusts or local governing bodies.

The operations of the First Mildura Irrigation Trust and the various Waterworks Trusts and local governing bodies, as well as the various Sewerage Authorities which control sewerage undertakings in country towns, are also subject to general supervision by the Commission.

2. **Systems Summarized.**—(i) *Works.* Since 1902, when a great drought emphasized the need for a concerted attack on water problems, the total capacity of water storages has increased from 172,000 to 4,929,550 acre feet (including Victoria's share of the Hume Reservoir). By means of channels, bores, etc., one-fourth of the State is artificially supplied for stock and domestic purposes. Large areas, which would be largely unproductive without water, are now contributing to the State's wealth. The area actually irrigated has increased from 105,000 acres in 1906 to 634,000 acres in 1955–56 and irrigation channels command 2,150,000 acres. However, owing to record or near-record rainfall, particularly in the northern districts the area irrigated in 1955–56 was some 25 per cent. below what could normally be expected.

The Commission controls 38 large reservoirs and 240 subsidiary storages. The capacities of the principal storages in acre feet within the various systems at 30th June, 1956 were as follows :—

Goulburn System :—Eildon Reservoir, 2,750,000 ; Goulburn Weir, 20,700 ; Waranga Basin, 333,400 ; Total, 3,104,100 ; *Murray–Loddon System* :—Half share of River Murray Commission storages including Hume, Yarrawonga, Torrumbarry, Euston, Mildura and Wentworth, 802,420 ; Cairn Curran, 120,600 ; Kow Swamp, Laanecoorie, Kerang–North-West Lakes, Lake Boga and Lake Cullulleraine, 148,210 ; Total, 1,071,230 ; *Wimmera-Mallee* :—Rocklands, 272,000 ; Total, 538,900 ; *Maffra-Sale* :—Glenmaggie, 106,040 ; *Coliban* :—62,730 ; *Werribee* :—34,900 ; *Mornington Peninsula* :—5,800 ; *Otway* :—1,080 ; *Miscellaneous* :—4,770 ; *Total* :—4,929,550.

Irrigation channels extend 5,000 miles, domestic and stock channels 9,500 miles and drainage and flood protection channels 2,000 miles, a total of 16,500 miles. In addition, the Commission controls 1,200 miles of piping, comprising 250 miles of mains and 950 miles of reticulation. Farm holdings served with water total 44,000. Urban districts with a reticulated water supply number 276, of which 130 are served by the Commission's channels and pipelines and 146 are supplied by Trusts under the supervision of the Commission. The total number of persons served by a reticulated water supply is 657,000 or 70 per cent. of the State's population outside Greater Melbourne.

To 30th June, 1956, the net capital expenditure on irrigation, rural water supply, country town water supply, and flood protection and drainage works amounted to £90,483,000, two-thirds of which was in respect of irrigation.

Of this net capital liability, at 30th June, 1956, £79,365,000 was borne by the State and £11,118,000 was borne by the water users. Waterworks Trusts and local governing bodies had a net capital liability of £8,422,000 at 30th June, 1956, of which £3,824,000 was borne by the State and £4,598,000 by the Authorities.

(ii) *Extent of Systems and Nature of Irrigated Culture.* Although the area irrigated is less than 2 per cent. of the State, it yields approximately 15 per cent. of Victoria's rural production. The following table shows the areas of the various irrigation systems and the areas under irrigated culture during 1955–56.

AREAS OF SYSTEMS AND OF LAND UNDER IRRIGATED CULTURE : VICTORIA, 1955-56.

(Acres.)

System.	Total Area.	Area under Irrigated Culture.									
		Cereals.	Lucerne. (a)	Other Fodder Crops.	Pastures.		Vineyards.	Orchards.	Market Gardens.	Fallow and Miscellaneous.	Total.
					Sown.	Natural.					
Goulburn	*1,257,916*	*757*	*15,878*	*5,541*	*183,115*	*13,507*	*237*	*17,813*	*3,462*	*5,224*	*245,534*
Murray—											
Torrumbarry Weir ..	377,596	2,411	4,540	2,282	114,985	18,564	5,637	1,678	1,674	1,898	153,669
Yarrawonga Weir ..	267,209	39	15,782	168	31,536	114	33	3,465	416	9	51,562
By Pumping ..	35,373	90	249	91	404	70	23,884	1,651	211	..	26,650
Total	*680,178*	*2,540*	*20,571*	*2,541*	*146,925*	*18,748*	*29,554*	*6,794*	*2,301*	*1,907*	*231,881*
Loddon and other Northern Systems ..	*(b) 19,736*	*146*	*1,099*	*267*	*10,760*	*1,786*	*7*	*3,940*	*990*	*1,014*	*20,009*
Southern Systems ..	*147,914*	*16*	*1,774*	*221*	*34,061*	*858*	..	*557*	*4,890*	*1,095*	*43,472*
Mildura and Private Diversions	*(c) 45,000*	*3,211*	*6,010*	*2,243*	*41,996*	*9,055*	*15,720*	*6,348*	*4,687*	*4,168*	*93,438*
Grand Total ..	2,150,744	6,670	45,332	10,813	416,857	43,954	45,518	35,452	16,330	13,408	634,334

(a) Includes lucerne for both hay and pasture. (b) Area of Campaspe District only. (c) Area of First Mildura Irrigation Trust only.

(iii) *Production.* The influence of irrigation on Victorian production has been considerable, the value of production from irrigation districts as estimated by the Commission having risen from £500,000 in 1905–6 to about £41 million in 1954–55. The major products of irrigated farms are : livestock for slaughtering, dairy products, wool, vine fruits, fresh and canning orchard fruits and vegetables.

3. **Goulburn System.**—This comprises the Eildon and Waranga Reservoirs, the Goulburn Weir and over 2,570 miles of distributory channels. The total capacity of these storages was 3,104,100 acre feet at 30th June, 1956. The Eildon Reservoir (capacity 2,750,000 acre feet) which was completed in June, 1955, is the largest dam in Australia and the largest earthen dam in the Southern Hemisphere. The enlargement of Eildon means that when the necessary distributory works are completed, the area at present irrigated from the Goulburn River can be practically doubled to 600,000 acres.

Water from Eildon Reservoir flows down the Goulburn for 150 miles to the Goulburn Weir, which raises the summer level of the river about 45 feet to 408 feet above sea level, and where water is diverted to two main channels. The eastern main channel conveys water to four irrigation districts surrounding Shepparton and the western main channel fills Waranga Basin in addition to supplying the eastern portion of the Rodney Irrigation District. Following completion of Eildon Reservoir, the latter channel has been duplicated to Waranga Basin.

Two main outlet channels issue from the Waranga Reservoir ; one serves the Western part of the Rodney district, while the other serves districts as far west as Boort, and continuing to Beulah East, about 230 miles by channel from Waranga Basin or some 400 miles from Eildon, supplements the Wimmera-Mallee system.

Districts served comprise 196,000 acres east of the Goulburn ; 602,000 acres between the Goulburn and Campaspe ; 380,000 acres between the Campaspe and Loddon ; and 80,000 acres west of the Loddon—a total of 1,258,000 acres.

The main products of the Goulburn districts are dairy products, fruit and wool and fat lambs. The development of the fruit canning industries is an index of the results of irrigation policy. Annual production from the Shepparton, Kyabram and Mooroopna canneries, together with that of city canneries—from Goulburn Valley fruit—amounts to an aggregate which normally represents about two-thirds of Australia's total production of canned peaches, pears and apricots.

4. **Murray River System.**—The waters of the River Murray are used to supply an area of more than 700,000 acres between Yarrawonga and Merbein, and channels totalling 1,450 miles are in service. The districts between Yarrawonga and Swan Hill, except Tresco, are supplied by gravitation and those down the river (Red Cliffs, Merbein, Nyah and Mildura) are supplied by pumping.

The Murray Valley Irrigation District, which is served from Yarrawonga Weir, comprises 267,000 acres with 550 miles of distributory channels. This district lies west of Yarrawonga between the River Murray and Broken Creek, its main products being dairying, fat lambs and deciduous fruit. A major post-war development has been a Soldier Settlement Scheme involving 60,000 acres. With the exception of the necessary drainage works, which are under construction, this project is complete.

Robinvale Irrigation District, between Swan Hill and Mildura is a soldier settlement project established after the 1939–45 War. Set up on modern lines, the 3,000 acres irrigated annually are showing good yields of fruit. About ninety per cent. of the area is devoted to dried vine fruits, and the remainder to orchards.

The gravitation system based on Torrumbarry Weir (52 miles downstream from Echuca) serves an area of 377,600 acres with 846 miles of supply channels. The weir raises the level of the river some 16 feet and enables water to be diverted throughout the year.

Red Cliffs Irrigation District comprising 13,600 acres, of which, at present, 11,650 acres are irrigated, ranks first in importance among Victoria's pumping schemes. A system of main and distributary channels commands every holding in the district. The district, originally for soldier settlement, has been subdivided into 700 blocks. The area is planted mainly with vines and citrus. The average harvest is now 18,000 tons of raisins, currants and sultanas as well as large quantities of grapes for dessert and distillation.

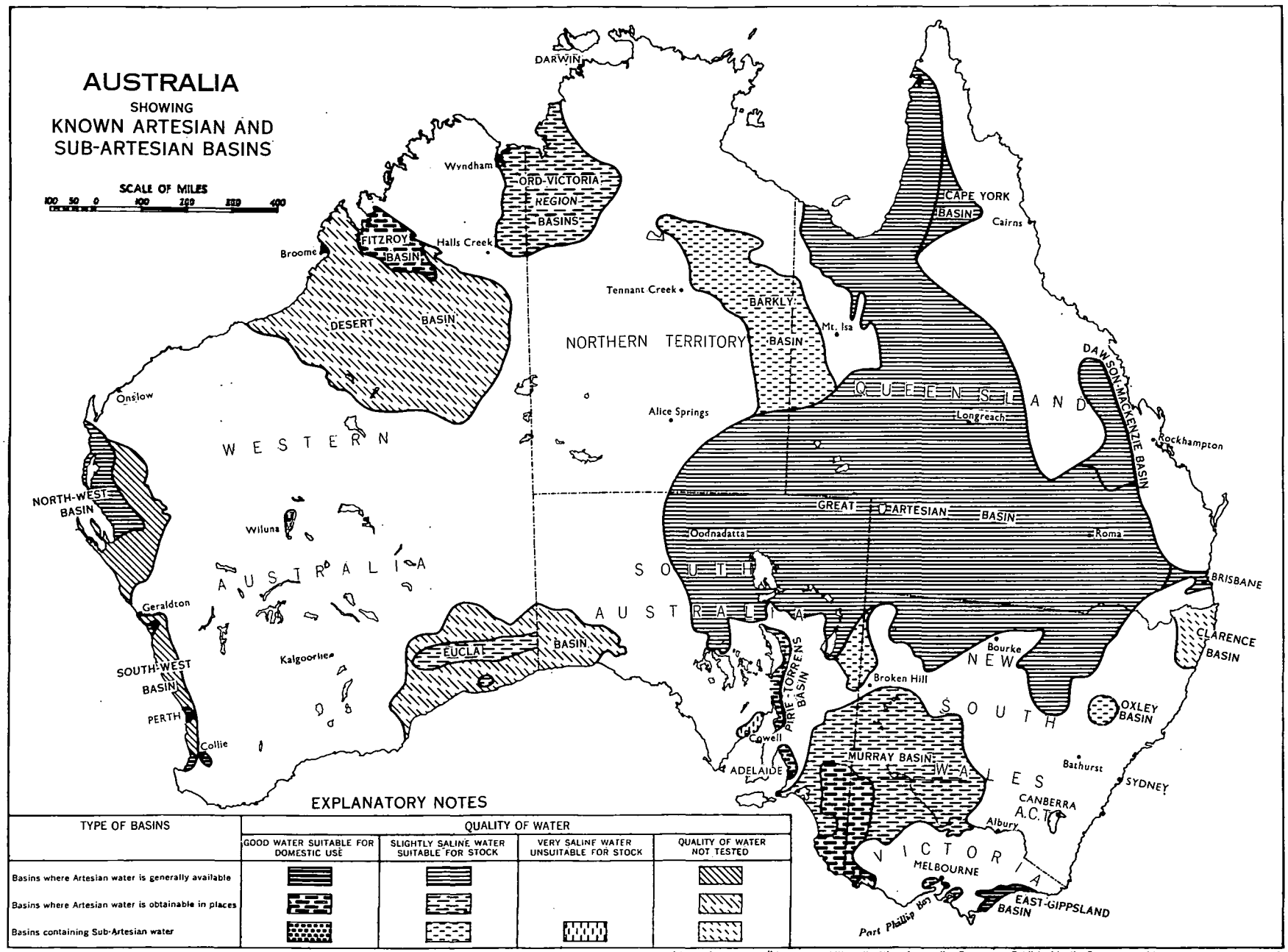
Merbein Irrigation District comprises 9,200 acres and contains over 300 holdings averaging about 30 acres each. A reticulated pipe system supplies the town of Merbein, and the pumps also supply 51,200 acres forming part of the Millewa Waterworks District.

Nyah Irrigation District is supplied with water diverted from the Murray by a high-lift pumping plant, serving 3,840 acres in about 200 holdings devoted mainly to vineyards.

5. **First Mildura Trust District.**—The First Mildura Irrigation Trust—the only Irrigation Trust operating in Victoria—controls an area of 45,000 acres, of which 15,000 acres are irrigated. Of this area, some 80 per cent. is used for the production of vine fruit and the bulk of the remainder for citrus and other fruit The Trust area produces approximately 15,000 tons of raisins, currants and sultanas each year. The irrigation water is pumped from the River Murray and distributed through 168 miles of channels.

6. **Wimmera-Mallee System.**—The Wimmera-Mallee scheme is regarded as the most extensive domestic and stock supply system in the world. The main supply is drawn from the Grampians storages with a capacity of 538,900 acre feet. Supplementary water is drawn from the Goulburn channels and the Loddon River. The system serves an area of 11,000 square miles or nearly one-eighth of the State, which is largely devoted to wheat and pastoral industries. Without the artificial supply of water, development would be meagre.

Once a year, in the winter or spring, a volume of 72,000 acre feet of water is distributed through 6,500 miles of open channels and some 3,000 miles of farm channels. It is the responsibility of farmers to provide storages sufficient in size to meet their stock and domestic requirements for the ensuing year. About 10,000 farmers' tanks are served. In addition,



EXPLANATORY NOTES

TYPE OF BASINS	QUALITY OF WATER			
	GOOD WATER SUITABLE FOR DOMESTIC USE	SLIGHTLY SALINE WATER SUITABLE FOR STOCK	VERY SALINE WATER UNSUITABLE FOR STOCK	QUALITY OF WATER NOT TESTED
Basins where Artesian water is generally available				
Basins where Artesian water is obtainable in places				
Basins containing Sub-Artesian water				

Adapted from the map" Underground Water " Atlas of Australian Resources : Published by the Department of National Development : 1953

forty-seven towns with a total population of 40,000 obtain their water from the system. A total population of 80,000 depends upon the scheme. In the vicinity of Horsham and Murtoa, near the main storage, 3,500 acres are irrigated for soft fruits and pastures. With the completion of the Rocklands Reservoir, this irrigation area is being extended to 7,000 acres.

The northern part of the system is affected by sand drifting into the channels, particularly in years of dry weather conditions, and the Commission is involved in substantial annual expenditure to remove this sand drift before the annual water distribution can be made. This expenditure can be reduced by better farming methods, and efforts in this direction such as the sowing of rye-corn, and including the use of compulsory powers to prohibit the fallowing of land or burning of stubble within three chains of channels in light sandy country have resulted in marked savings in maintenance costs.

7. **Private Water Supplies.**—The Rural Finance Corporation Act 1949 gave farmers assistance in establishing or improving domestic and stock water supplies on their farms. Water may be obtained from underground sources, from catchment and gully dams by diversion from existing streams and channels, by storage of sufficient water to meet a year's requirements and by installation of windmills or hydraulic rams.

The control of private diversions from the streams is an important function of the State Rivers and Water Supply Commission. About 10 per cent. of irrigation production in the State comes from private diverters, mainly around the River Murray. In recent years, there have been substantial increases in the areas licensed, the total increase over the past ten years being approximately 50 per cent.

A Farm Water Supplies Branch set up by the State Rivers and Water Supply Commission advises farmers on farm water supply matters even if finance is not required. Comprehensive booklets prepared by this Branch have been widely circulated to landholders.

8. **River Improvement, Flood Protection and Drainage.**—The largest drainage work undertaken by the State Rivers and Water Supply Commission is Koo-wee-rup-Cardinia Flood Protection District embracing 80,000 acres of a continuous depression along the seaboard of Westernport. Once useless, indeed a hindrance to communication, this area now yields primary products of considerable value.

The Rivers and Streams Fund, established in 1931 from the rentals on river frontage reserves, gave an impetus to river improvement, but development accelerated rapidly after the 1948 River Improvement Act.

Under this Act, the formation of River Improvement Trusts is facilitated, assistance being granted by the State Government to supplement funds raised locally, and the importance of river improvement work is expected to continue to grow.

9. **Underground Resources.**—Due to inadequate information as to their extent, the underground waters of Victoria as yet have not been greatly utilized. The first stage of a comprehensive survey of these resources by the Victorian State Rivers and Water Supply Commission, which is responsible for the location, investigation and development of subterranean waters, has been completed and published recently. It provides records of bores in the Mallee, Wimmera and Glenelg regions, and a description of the Murray Artesian Basin. Investigations have also been made into the underground water resources of local areas such as Orbost Flats, Llowalong Estate on the Avon River and elsewhere.

The Murray Artesian Basin underlies an area of 107,250 square miles, of which 26,808 square miles are in Victoria, 28,269 square miles in South Australia and 52,173 square miles in New South Wales. The quality of the water varies from suitable for domestic purposes in much of the South-western part of the basin to saline and suitable for stock in the rest of the basin. Over 300 bores exist in Victoria, with an average daily flow of 3,000,000 gallons. Bores range in depth from 50 to 3,000 feet.

10. **Future Programme.**—With the completion of the Eildon and Cairn Curran Reservoirs, storage capacity in Victoria has risen from 172,000 acre feet in 1902 to nearly 5,000,000 acre feet in 1956. In the near future, as a result of the enlargement of the Glenmaggie and Hume Reservoirs, a further increase of 600,000 acre feet of storage capacity will become available.

The most important work at present facing the Commission is the enlargement of the Goulburn Channel System to enable full advantage to be taken of the additional water now available from Eildon Reservoir. The total cost of the work to be carried out is estimated at £10 million. Major works involve the enlargement of the Waranga Western

and East Goulburn Main Channels. However, it will be possible to develop the present districts progressively before the whole operation is completed and in the meantime, the water already stored in the Eildon Reservoir will provide a valuable safeguard against any possible drought.

11. **Hydro-electricity.**—Details of hydro-electricity potential and utilization in Victoria may be found in the previous chapter (*see* page 276).

§ 4. Queensland.

1. **General.**—(i) *Rainfall.* Particulars of the rainfall pattern of Queensland were given in Official Year Book No. 37, page 1122. (*See also* Chapter II.—Physiography, page 45 of this issue).

(ii) *Administration.* The administration of irrigation and water supply in Queensland is under the control of a Commissioner of Irrigation and Water Supply. For a description of the development of the present administration *see* Official Year Book No. 42 and earlier issues.

(iii) *Water Utilization in Queensland.* Queensland's predominant interest in the field of water conservation is the provision of stock and domestic water supplies in its great pastoral areas which contain nearly half of the Commonwealth's cattle and a seventh of the sheep. But in addition to the stabilization of water supplies in the pastoral areas and the provision of water along stock routes for travelling stock, the development of irrigated pastures on the eastern seaboard for fattening stock adjacent to meat works and markets has received much attention in later years.

The State's agricultural crops differ from those of other States in that a large proportion are tropical. Sugar-cane is the greatest individual crop, representing in value approximately 50 per cent. of total agricultural production. Approximately 16 per cent. of the sugar-cane acreage is irrigated and represents some 43 per cent. of the total irrigated area in Queensland. Queensland is Australia's major tobacco-producing State, and plans are in hand to increase annual production of this crop greatly by means of development under irrigation. The area of tobacco irrigated during 1955–56 represented 88 per cent. of the total plantings of this crop in the State.

2. **Great Artesian Basin.**—(i) *General.* Western Queensland beyond the 20 inch rainfall belt is predominantly pastoral and is mainly dependent for water supplies on artesian and sub-artesian bores and, where surface storage is not readily available, on excavated tanks. The Great Artesian Basin in Queensland corresponds approximately with the area lying west and south of the Great Dividing Range, excluding the Cloncurry Mineral Field and the Barkly Tableland. It comprises 430,000 square miles or about two-thirds of the total State area of 670,500 square miles. Statistics of bores and flow as at 30th June, 1956, are :—Artesian bores drilled, 2,482 ; artesian bores still flowing, 1,579 ; total depth drilled, 3,537,000 feet ; deepest bore, 7,009 feet ; total estimated flow, 212 million gallons per day. The average depth of artesian bores is 1,440 feet. Some 9,000 sub-artesian bores, within the Great Artesian Basin, have been registered in Queensland. Artesian pressure and flow are both steadily diminishing despite new bores drilled. The rate of diminution varies widely throughout the basin. Present general average rates of diminution are :—pressure, 1–2 feet/head, total flow, 1½–2 per cent. per annum.

The greater part of the artesian discharge is distributed by open earth channels totalling some 16,000 miles in length. Most of the water flowing along these channels is lost by soakage and evaporation and less than 10 per cent. is actually used by stock. The amount of soakage depends largely on the permeability of the earth and the rate of evaporation varies from season to season, but the shape and maintenance of the drains constitute further factors. The effective utilization of this water could be increased by the use of piping to overcome the loss by soakage and evaporation occurring in open earth channels.

Although artesian beds underlie such a large area of the State, only 80,000 square miles are primarily watered by bore drains. The remaining area is watered by artesian bores (with small or no flow and limited drains), sub-artesian bores, excavated tanks, dams and natural waterholes. In many districts, artesian bores are not economical watering facilities, because of depth, limited area to be watered, and difficult terrain for distribution of water by drains. High costs have restricted deep drilling. Very few new bores exceed 2,000 feet in depth, and a new bore greater than 3,000 feet in depth is exceptional.

Shallow sub-artesian supplies, of variable quality and volume, are available at depths less than 1,000 feet over a large area of the basin. These beds are not connected with the artesian beds. An essential practical consideration is that the main artesian beds are continuous and the sub-artesian beds are not continuous.

Though the number of bores has gradually increased over the years, the total flow of all bores has declined since the peak flow of 351 million gallons per day was recorded in 1914. By 1938, the flow was only 230 million gallons per day. The decline gave rise to the fear that supplies were giving out and that the basin was seriously threatened. In 1939, the Queensland Government appointed a committee to ascertain the nature and structure of the Great Artesian Basin with particular reference to the problem of diminishing supply. In its final report, presented in 1954, the majority of the Committee found that the output will continue to decline during the next sixty years when the flow from the remaining flowing bores will be of the order of 110 million gallons per day. At this stage the discharge from windmills, springs and other leakages and the underflow past the Queensland borders will be of the order of 20 million gallons per day. The total discharge of the order of 130 million gallons per day will be in equilibrium with the recharge of the basin. Numbers of bores on higher ground will cease to flow during the next sixty years and the area served by flowing bores will contract by perhaps 20 per cent.

A programme of strict conservation, involving the restriction of bore flows and improved bore drains, would result in smaller shrinkage of the area served by flowing bores and would actually cost less than the installation and maintenance of pumps or other watering facilities which would be required to provide alternative water supply as additional bores ceased to flow as a consequence of a policy of non-restriction. On the other hand, strict conservation would not increase the amount of water ultimately available as perennial flowing supply and would in fact decrease the amount of water passed from intake beds to aquifers within the basin by flattening the hydraulic gradient. The benefit from strict conservation was not considered sufficiently great, nor sufficiently concrete to warrant implementation.

The quality of artesian water from the greater part of the basin is such that it is not suited for prolonged use for irrigation on most soils. Moreover, artesian supplies are not sufficient for both large scale irrigation and stock-watering. Practically the whole of the final steady-rate discharge from flowing bores will be needed for the watering of stock.

In the past, many excavated tanks failed in dry seasons, because of insufficient original depth and capacity, and subsequent silting. Mechanical plant is now almost exclusively in use and much larger tanks are being excavated, even in areas where artesian water may be obtained at a reasonable depth. New tanks with capacities of 20,000 cubic yards and depths of 25 feet are not uncommon. Two tanks with capacities of 65,000 cubic yards each, and depths of 42 feet and 46 feet respectively have been completed for watering stock in an area where a good artesian flow may be obtained at a depth less than 2,000 feet.

(ii) *Bore Water Areas.* The constitution of Bore Water Areas was inaugurated in 1913 to aid pastoral settlement in districts where large flows were available at a cost beyond individual capacity and to conserve artesian supplies by fully utilizing the flows from the existing bores on the land resumed for closer settlement. Bores and drains are constructed from loan funds repayable over a period of years. The areas are administered by Local Boards or by the Commissioner of Irrigation and Water Supply, acting as a Board. Rates are levied to meet interest, redemption, maintenance and administration costs. Statistics for the year 1955–56 are :—Areas constituted, 63 ; administered by Commissioner, 56 ; administered by Local Boards, 7 ; area benefited, 4,572,162 acres ; average rate per acre, 1.16d. ; number of flowing bores, 56 ; total flow, 24,943,000 gallons per day ; drains served, 2,822 miles.

3. **Other Basins.**—Two major areas marginal to the Great Artesian Basin in Queensland carry artesian water. One occurs on the western slopes of Cape York Peninsula and the other in the Dawson-Mackenzie River Basin (*see* Map, page 307). A small area in which flowing wells occur (the Gatton Basin) extends from Gatton to the coast.

Sub-artesian water supply from the Barkly Basin which extends into western Queensland from the Northern Territory, is referred to in the section dealing with the Northern Territory.

4. **Stock Route Watering.**—During 1935, a scheme was inaugurated to water stock routes adequately in the western portion of the State including main trunk routes connecting Eromanga to Burketown, Charleville to Normanton, and Clermont to Einasleigh, with branches to railheads, a total distance of 3,117 miles. Watering facilities were also

provided on subsidiary routes. Under the Stock Routes and Rural Lands Protection Act of 1944, a co-ordinating board was constituted, representative of Government departments and pastoral interests, under the direction of the Minister for Lands, and with an officer of that Department as superintendent, whose duty was, *inter alia*, to investigate and implement a long-range, co-ordinated plan for adequate watering of all stock routes throughout the State. Natural waters are being supplemented by artificial facilities at intervals of about 9 miles. Construction is supervised by the Irrigation and Water Supply Commission and by local authorities. Completed facilities are vested in local authorities for control and maintenance. From 1935 to 30th June, 1956, 380 facilities had been completed and at 30th June, 1956, 113 facilities were under construction or investigation.

5. **Irrigation.**—(i) *General.* Irrigation as a means of stabilizing and increasing agricultural production is receiving growing attention in Queensland. In addition to the Theodore Irrigation Area on the Dawson River, orthodox projects served by a channel system are being developed at Clare, Millaroo and Dalbeg, all on the Burdekin River, Gibber Gunyah on the Dawson River and St. George on the Balonne River. Construction of the Clare and Millaroo Irrigation Areas is nearing completion whilst at Dalbeg, Gibber Gunyah and St. George construction is well advanced. A start has been made on construction of part of the main channel system within the Mareeba-Dimbulah Irrigation Area. Because of the large variations in both monthly and annual river flows, major developments cannot be undertaken until large storage works are provided. Most irrigation in Queensland is performed by private farmers operating under licence, and obtaining water by pumping from streams or from natural underground storages. Where available, electricity is the most popular source of power for pumping ; the principal areas supplied with electricity comprise the Burdekin Delta and the Lockyer Valley.

Furrow irrigation is used for cotton, sugar cane, most tobacco and some other crops. Spray irrigation is adopted to a considerable extent for fruit, vegetables, fodder crops and a small part of the tobacco. Spraying is well suited to the application of water on deep soils by small pumping plants, particularly when the quantity of water available is limited. Experimental use of the border check method in the irrigation of pasture and fodder crops has proved successful and may supersede other methods.

The following table shows for each division of the State the number of irrigators and the areas under irrigated culture for the year ended 31st March, 1956.

AREA OF LAND UNDER IRRIGATED CULTURE : QUEENSLAND, 1955-56.(*a*)

Division.	No. of Irrigators.	Area under Irrigated Culture (Acres).							
		Vegetables.	Fruit.	Sugar-cane.	Tobacco.	Cotton.	Other Crops.	Pastures.	Total.
Southern Queensland ..	3,831	15,420	2,806	9,943	1,626	31	20,470	22,507	72,803
Central Queensland ..	341	668	140	..	1	568	2,946	508	4,831
Northern Queensland ..	1,529	3,740	725	48,819	3,918	86	550	547	58,385
Total	**5,701**	**19,828**	**3,671**	**58,762**	**5,545**	**685**	**23,966**	**23,562**	**136,019**

(*a*) Year ended 31st March, 1956.

The growth of irrigation is illustrated by the following figures for the total area of irrigated land :—1906, 9,922 acres ; 1916, 10,886 acres ; 1926, 24,250 acres ; 1935–36, 44,283 acres ; 1945–46, 68,347 acres ; 1955–56, 136,019 acres.

The pattern of irrigation in Queensland is unlike that in southern States ; the more important developments in tropical and sub-tropical areas are therefore discussed briefly in the sub-sections following. It should be noted that the spring to autumn " irrigation season " of the temperate southern irrigated lands is not applicable, and that round-the-year irrigation is required throughout most of the State, the timing and duration of the summer " wet " season being too variable to enable a definite non-irrigation season to be fixed.

(ii) *Lockyer Valley.* West of Brisbane and within 30 miles of that metropolitan market is the Lockyer Valley, which is portion of the Brisbane River Basin. The Valley comprises an extensive flood plain where heavy black alluvial soil thickly overlies gravels and sands carrying water suitable for irrigation. Despite a mean annual rainfall of 30

inches the variation is great, and irrigation is necessary for continuous agricultural production. Surveys suggest that some 60,000 acres of land highly suitable for irrigation are available. Of this area, only about 30 per cent. is under irrigation, the number of pumps operating from wells and open water exceeding 550 and 600 respectively. Over 60 per cent. of the farmers operate electric pumps for irrigation purposes and a special policy designed to encourage such development is fostered by the Southern Electric Authority of Queensland. The Irrigation and Water Supply Commission has constructed a number of small weirs on Lockyer Creek with a total storage of 1,370 acre feet. These also tend to augment and conserve underground supplies. To study local problems, an Irrigation Research Station was established at Gatton in 1946 by the Bureau of Investigation.

The Lockyer Valley produces a substantial proportion of Queensland's onions, potatoes, pumpkins, lucerne, hay, green fodder, maize and dairy products.

(iii) *Burdekin River.* The Burdekin River, which joins the sea between Townsville and Bowen, is a major factor in the life of North Queensland. In most years heavy floods from a catchment twice the size of Tasmania cause extensive damage and traffic disabilities. On the other hand, the fertile Delta Area with its underground water supplies at shallow depth has contributed greatly to the agricultural prosperity of North Queensland. Present development is confined to the Delta Area. The average annual rainfall of this area is some 41 inches, but the major part falls in the months December to March. Consequently sugar growers and other farmers have tapped the underground water resources of the Delta to obtain supplies in the dry periods. Sugar is the main irrigated crop, though citrus, pine-apples, vegetables and tobacco are also irrigated. The irrigated area is in excess of 30,000 acres, up to 1,000 acre feet of water being drawn daily from underground sources.

In the Home Hill–Inkerman areas on the south side of the Burdekin, water is obtained from shallow wells by electric pumps supplied from a local power station controlled by the Townsville Regional Electricity Board. Around Ayr, on the north side of the river, electric power from the mains of the Townsville Regional Electricity Board is now being adopted in place of the individual internal combustion engines previously used. At both Home Hill and Ayr, water for domestic supply is raised by a windmill on each property.

In 1940, the Burdekin River Trust was formed to safeguard the sugar areas of the Delta from erosion and floods. An Irrigation Research Station has recently been established to study the development of pastures and irrigated crops under local conditions.

A major multi-purpose scheme, involving irrigation, flood control and hydro-electric power generation, is being investigated by the various interested Government Departments under the general supervision of the Burdekin River Authority. The development envisaged includes a dam storing 6,584,000 acre feet, which would make water available for the irrigation of at least 250,000 acres. The principal industries anticipated are tobacco-growing, dairying and cattle fattening, with sorghum, sunflowers, peanuts, cotton and sugar-cane as other possible forms of production. The projected scheme, together with the high-level railway bridge at present under construction, will change the Burdekin from a mixed blessing to one of the Commonwealth's greatest resources for agricultural and industrial production.

The Clare Irrigation Area, constituted in 1949, the Millaroo Irrigation Area, constituted in 1952, and the Dalbeg Irrigation Area, constituted in 1953, are at present being developed for tobacco production. Located from 25 to 65 miles upstream from the mouth of the Burdekin, these areas comprise 12,000 acres and obtain irrigation waters from central pumping stations drawing initially on the unregulated flow of the Burdekin. A temporary storage of 6,700 acre feet capacity has been constructed about 79 miles upstream from the mouth of the Burdekin. To 30th June, 1955, 71 farms had been opened for selection in the Clare Area, 58 in the Millaroo Area and 37 in the Dalbeg Area.

(iv) *Dawson Valley.* The Dawson River, a 392-mile long tributary of the Fitzroy River, rises in the Carnarvon Range and joins the Mackenzie River to form the Fitzroy 50 miles west of Rockhampton. Lands bordering the river in its northerly course of about 170 miles before its confluence with the Mackenzie River are commonly termed the Dawson Valley. A scheme for the development of the Dawson Valley under irrigation was inaugurated in 1923, providing for the irrigation of 70,000 acres. Storage for the scheme was to be provided by a dam of 2,000,000 acre feet capacity at Nathan Gorge. Much investigational and survey work on the scheme was carried out, but the general financial depression and limited loan funds brought about the cessation of this work. However, the initial step in construction had been completed, comprising a weir on the river at Theodore and irrigation works to serve an area of 3,500 acres supplied from a central

pumping station. Two additional weirs have since been built, giving a total storage of 9,000 acre feet. Pasture, vegetables, cotton, fruit and dairy products are the principal produce. Attention has recently been given to the former plans for the Valley and earlier work is now under close scrutiny as a prelude to future development. Construction of works to serve some 2,400 acres at Gibber Gunyah, adjacent to the existing Theodore Area, is in progress.

(v) *Mareeba–Dimbulah Area.* The existence of large areas of sandy soils suitable for tobacco production in the valleys of the Walsh and Barron Rivers in the neighbourhood of Mareeba and Dimbulah has led to large-scale investigations into possible irrigation development in the area. Surveys indicate that 40,000 acres of land suitable for irrigated culture, including 32,000 acres suitable for tobacco, are available. In 1955–56, some 3,026 acres of high-grade tobacco were grown. Seven weirs of combined capacity of 2,600 acre feet have been completed on a number of streams to store water for irrigation.

During 1952, a report on the utilization of waters of the Barron and Walsh Rivers was prepared and the establishment of an irrigation undertaking approved by the Queensland Government. The projected undertaking provides for construction of a major storage at Tinaroo Falls on the Barron River to store 320,000 acre feet, and construction of irrigation works to serve 78,000 acres commanded by this storage. In each case, construction has commenced. Further development by construction of a second storage at Nullinga on the Walsh River has been deferred for the present. Tobacco will be the basic crop while peanuts, vegetables, maize, cotton and stock fattening also appear suitable.

(vi) *Border Rivers Project.* The development of the rivers constituting portion of the border between Queensland and New South Wales is under the authority of the Dumaresq-Barwon Border Rivers Commission on which each State is represented. For information on the project *see* page 296.

(vii) *Balonne River.* The St. George Irrigation Area has been constituted and construction of works to serve some 11,000 acres is in progress. Water supply for the area will be obtained by pumping from the combined weir and road bridge on the Balonne River at St. George.

6. **Bureau of Investigation.**—Under the Land and Water Resources Development Act of 1943, a Bureau of Investigation has been set up for the co-ordinated investigation of land and water resources development.

The Bureau consists of representatives from the authorities controlling water resources, lands and agriculture, under the chairmanship of the Co-ordinator-General of Public Works. Among notable works carried out by the Bureau of Investigation since its inception has been the trial planting of irrigated pastures with a view to developing mixtures suited to the special conditions of each part of the State. Other valuable work has included the mapping of the ultimate land uses of the State and the detailed investigation of the agricultural and pastoral potentialities of many regions.

7. **Channel Country.**—Extensive investigations of the Channel Country fed by inland rivers in the south-western corner of the State have been made by the Bureau of Investigation. This country is intersected by shallow and irregular flood channels through which huge volumes of flood waters pass in favourable seasons ; consequent on the flooding, a heavy growth of natural pastures is produced on the flooded lands, providing feed in quantities far in excess of that required for the normal stock population of the area. If the occurrence of flooding could be made more reliable by means of storages to create artificial floods, the pastoral resources of the area would be enormous. However, inquiries directed on these lines have revealed that little can be done to increase or stabilize the turn-off of fat cattle by artificial storage.

At 30th June, 1952, 41 watering facilities, at an estimated cost of £277,000, had been proposed under a Federal-State agreement for stock routes through, and in the approaches to, the Channel Country. By 30th June, 1956, twenty-five had been completed. In addition, nine large excavated tanks and two bores were finished, but still required equipping with windmills, tanks and troughs.

8. **Hydro-electricity.**—An outline of Hydro-electricity Schemes operating in Queensland is given in the previous chapter (*see* page 279).

§ 5. South Australia.

1. General.—(i) *Rainfall.* Brief particulars of the climatic conditions in South Australia were given on page 1129 of Official Year Book No. 37. (*See also* Chapter II.—Physiography, p. 45 of this issue.)

(ii) *Administration.* Water supplies, other than irrigation works, are under the control of the Engineering and Water Supply Department, which administers the Waterworks Act governing the supply of water through mains in water districts for townships and farm lands. The Water Conservation Act provides for the construction of storages in non-reticulated areas and authorizes the Minister to " divert and impound the water from any streams or springs or alter their courses, and take water therefrom, or any other waters as may be found in, under, or on, any land entered upon for the purpose of supplying water to the inhabitants of any water district ".

(iii) *Methods of Catchment and Conservation.* Early steps were taken to vest all running streams, springs and " soaks " in the Crown. Since the Water Conservation Act was passed in 1886 more than 550 dams, tanks and " rainsheds " have been built or acquired by the State, in addition to 460 wells and 340 bores, at a total cost of £1,653,468. The rainsheds comprise timber frameworks roofed with galvanized iron to catch precipitation which is delivered to storage tanks. Rainshed catchments vary from a few hundred square feet to four acres, discharging water into tanks ranging in capacity from 2,000 to 500,000 gallons. Over most of the State extraordinary precautions are taken to counteract evaporation. Pipelines in preference to open channels are used to reduce seepage and evaporation. Meters are attached to practically all services to check usage by individual consumers.

2. Irrigation.—In South Australia, irrigation is almost exclusively confined to the Murray Valley. Except for that held in various lock pools, no water from the Murray is stored in South Australia. Water is either pumped on to the land or gravitated from the river. The upper Murray of South Australia and the Mildura area of Victoria formed the cradle of Australian irrigation. South Australian irrigation commenced with an agreement between the Government and the Chaffey brothers in 1887 whereby an area of land at Renmark was made available for the establishment of certain irrigation works. Including land allotted for War Service Land Settlement purposes, the Department of Lands administers in the Murray Valley an area of 32,659 acres of irrigable high land together with 9,432 acres of reclaimed swamp and 167,090 acres of non-irrigable land in the irrigation areas and 29,898 acres of land temporarily leased and reserved for commonage or other purposes, amounting in all to 239,079 acres. In addition, the Renmark Irrigation Trust controls 20,557 acres, of which more than 9,000 are irrigated. Water used for irrigation purposes in 1955–56 in the high land irrigation areas controlled by the Department of Lands, excluding War Service Land Settlement areas in course of development, was approximately 100,000 acre feet, in addition to which approximately 60,000 acre feet were used on reclaimed areas by gravitational watering. In the Renmark area, 29,600 acre feet of water were used for irrigation in 1955–56. The production of the upper Murray areas is almost exclusively fruit and vines. Principal crops are sultanas, currants, lexias, apricots, peaches, nectarines, pears and figs (mainly for dried fruit), wine grapes, and citrus fruits. Before irrigation, these semi-arid lands were of little productive value.

Renmark Irrigation Trust is administered by a local board of management consisting of seven members. This area differs from other South Australian irrigation areas in that the land is freehold instead of leasehold, self-contained and self-controlled. Every settler is entitled to vote for the election of Trust members. The Trust maintains 100 miles of channel for reticulation to 9,310 acres.

The following tables show the acreage devoted to various crops in the government-controlled and Renmark Irrigation Trust areas on the upper Murray, and in the government-controlled reclaimed swamp districts near the mouth of the Murray, which are devoted to dairying.

AREA OF LAND UNDER IRRIGATED CULTURE 1955–56.

IRRIGATION AREAS ADMINISTERED BY THE DEPARTMENT OF LANDS AND THE RENMARK IRRIGATION TRUST.

(Acres.)

Area.	Vine Fruits.	Tree Fruits.	Citrus Fruits.	Lucerne.	Sown Pastures.	Total.
Areas Administered by the Department of Lands.						
Orchard Land—						
Berri	5,346	938	1,252	..	..	7,536
Cadell	595	142	109	..	..	846
Waikerie	1,986	497	1,201	..	..	3,684
Cobdogla	3,897	127	148	..	..	4,172
Moorook	385	131	189	..	..	705
Kingston	246	63	202	..	..	511
Mypolonga	..	347	490	..	..	837
Chaffey—Ral Ral Division	792	55	11	..	..	858
Total	*13,247*	*2,300*	*3,602*	..	..	*19,149*
War Service Land Settlement—						
Cooltong Division ..	383	241	483	..	..	1,107
Loxton area ..	3,045	1,021	1,982	..	..	6,048
Loveday Division ..	235	47	22	..	..	304
Total	*3,663*	*1,309*	*2,487*	..	..	*7,459*
Reclaimed Swamp Land—						
Monteith	..	..	..	56	1,000	1,056
Mypolonga	..	..	..	79	1,312	1,391
Wall	..	..	..	26	478	504
Burdett	..	..	..	8	104	112
Mobilong	..	..	..	23	364	387
Long Flat	..	..	..	82	332	414
Neeta	..	..	..	7	683	690
Pompoota	..	..	..	..	418	418
Cowirra	..	..	..	18	423	441
Jervois	..	..	..	83	3,543	3,626
Total	..	..	..	*382*	*8,657*	*9,039*
Renmark Irrigation Trust.						
Renmark Irrigation Trust	*7,330*	*780*	*1,200*	..	..	*9,310*

3. **Water Supply Schemes.**—(i) *Summary.* Water conservation and distribution works in South Australia have cost £47,006,967 (exclusive of river control and irrigation works on the River Murray which are dealt with above). A summary of statistical information concerning country supplies in 1955-56 is as follows :—Length of water mains, 5,857 miles ; capacity of storages, 35,092 acre feet ; approximate population served, 289,000; area served, approximately 4,500,000 acres ; total capital cost, £25,842,611.

Areas extending for a distance of 90 miles north of Adelaide are supplied from the Warren and Barossa Reservoirs in the Barossa Ranges. Further developments currently being undertaken include the construction of a main pipeline and pumping stations for pumping water from the River Murray to Adelaide and, by means of a branch pipeline, to Warren Reservoir. Another reservoir (South Para Reservoir), to supplement the Warren and Barossa Reservoirs, is also being constructed on the South Para River. Agricultural towns and areas further north are supplied from Beetaloo, Bundaleer and Baroota Reservoirs, with a connexion to the Warren system. Eyre Peninsula has, up to the present, been supplied from the Tod River Reservoir (9,167 acre feet) and three small reservoirs near the Franklin Harbour District, but demands have increased to such an extent in recent years that further sources of supply are necessary, and with this end in view a water-bearing area known as the Uley-Wanilla Basin has been developed, and water from it is now being used in the Tod River system.

(ii) *Morgan-Whyalla Water Supply Scheme.* For particulars of the construction and works of the main 223-mile pipe line bringing water from the Murray at Morgan to Whyalla on Spencer Gulf *see* Official Year Book No. 37, page 1132. A 19-mile branch-line has also been constructed to Jamestown. The Morgan-Whyalla Water Supply Scheme forms part of the South Australian Country Water Supply system referred to above.

4. **Underground Water.**—The occupied portion of South Australia is, on the whole, well endowed with underground water and the extent of the several artesian basins is reasonably well known. There are also considerable areas, notably in the south-east of the State, in which ground water occurs. Quality varies widely, but a great deal is at least useful for watering stock, the major use to which it is put.

The deepest portion of the Great Artesian Basin (in the north-east) is not extensively developed because development costs are large in proportion to the carrying capacity of the arid land. However, deep boreholes have been drilled by the Government to provide watering places along stock routes, and pastoralists rely largely on supplies from non-pressure aquifers at shallower depths.

The use of the waters of the Murray Basin is essential to settlement in the Murray Mallee country and in the south-east of the State, especially for farms, but also for township supplies to Mount Gambier, Naracoorte, Bordertown, Pinnaroo and Penola. The deepest township borehole is 357 feet.

Pastoralists, farmers, market gardeners and others have been assisted with expert advice on drilling, for which the Government maintains about 30 drills. The whole of the Murray River Basin has been examined critically to ascertain the extent of land which could be used for lucerne and considerable tracts of previously undeveloped country in the Upper South-east, Kangaroo Island and Yorke Peninsula have been found to have usable water and are now being opened up.

Ground water resources surveys are undertaken continuously by Departmental geologists, the results being published in various bulletins, reports and investigations issued from time to time.

5. **Farm Water Schemes.**—While the Department of Mines and Engineering and Water Supply Department give assistance to individual farmers in the provision of supplies from underground sources, a great part of the farming areas derive water supply under pressure from the extensive distribution systems connected to various reservoirs on the Murray River.

6. **South-Eastern Drainage.**—For some information on the drainage schemes necessary for the disposal of surplus water in areas in the south-east of South Australia *see* Official Year Book No. 37, page 1133.

§ 6. Western Australia.

1. **General.**—(i) *Rainfall.* Brief particulars of the climatic conditions in Western Australia were given on page 1133 of Official Year Book No. 37. (*See also* Chapter II.—Physiography, p. 45 of this issue.)

(ii) *Administration.* Irrigation districts are administered under the Rights in Water and Irrigation Act 1914–1951 and the Government is advised by an Irrigation Commission representing the local irrigationists and government technical and financial branches. The Goldfields Water Supply is administered by a branch of the Public Works Water Supply Department and its responsibilities include control of water from this scheme for country

towns, mining and agricultural purposes. The metropolitan water supply is controlled by a separate department under the control of the Minister for Water Supply, Sewerage and Drainage. Under the Water Boards Act 1904–1953, twelve towns are administered by local water boards and 45 are under direct Ministerial control. The Minister also controls three District Farming Schemes. Water rights over water flowing in streams and water courses are vested in the Crown unless specifically appropriated for irrigation purposes under the irrigation legislation.

2. **Irrigation.**—The main irrigation districts—Harvey, Waroona and Collie—are along the south-west railway line between Waroona (70 miles from Perth) and Dardanup (116 miles from Perth). The total area irrigated in these districts during 1955–56 was 24,329 acres and the total water used was approximately 75,000 acre feet. The total acre waterings (i.e., the number of acres watered multiplied by the average number of waterings) were 118,426. Investigations are being carried out with a view to irrigating a further 30,000 acres south of the existing Collie Irrigation District.

Harvey Districts (Nos. 1 and 2—36,823 acres) are supplied from the Harvey Weir (8,300 acre feet) and Stirling Dam (44,344 acre feet), Waroona District (10,302 acres) from Drakesbrook Dam (1,855 acre feet) and Samson Brook Dam (6,540 acre feet), and Collie District (36,020 acres) from Wellington Dam (31,800 acre feet).

The following table, which shows acre waterings supplied to crops in the irrigation districts of Harvey, Waroona and Collie during the seasons 1950–51 to 1955–56 illustrate the growth of these irrigation schemes.

IRRIGATION, WESTERN AUSTRALIA : ACRE WATERINGS(*a*).

Year.	Pasture.	Fodder.	Potatoes.	Vegetables.	Orchard.	Flax, Broom Millet, and Preparation of Ground.	All Crops.
1950–51	76,431	793	2,946	4,090	1,180	..	85,440
1951–52	88,091	1,417	2,793	2,442	1,088	..	95,831
1952–53	95,491	2,235	4,185	2,588	1,070	536	106,105
1953–54	98,645	3,435	4,405	3,003	1,072	115	110,675
1954–55	112,659	3,268	2,363	3,294	845	121	122,550
1955–56	108,468	3,599	1,834	3,452	946	127	118,426

(*a*) Number of acres watered multiplied by average number of waterings.

In 1955–56 the total area irrigated in Western Australia was 37,164 acres made up of vegetables (6,880 acres), fruit (4,768 acres), vineyards (463 acres), pastures (23,328 acres) and other crops (1,725 acres).

3. **Water Supply Schemes.**—(i) *Goldfields Scheme.* Western Australia has one of Australia's most spectacular water supply schemes, and a brief account of its development will be found on page 1134 of Official Year Book No. 37, and an account in greater detail on page 576 of Official Year Book No. 6. Mundaring reservoir on the Helena River, 26 miles from Perth, is the source of water supplied to the goldfields, and has a capacity of 55,460 acre feet and a catchment of 569 square miles. The water now passes through 350 miles of main, mostly steel and 30 inches in diameter, aided by seven pumping stations and one booster station, involving a total net lift of 1,280 feet.

Maximum pumping capacity from No. 1 Pumping Station at Mundaring is now 12.2 million gallons per day. The total capacity of all receiving and regulating tanks, etc., along the pipe line is 154 million gallons, which includes three standby reservoirs at Kalgoorlie having a combined capacity of 60 million gallons.

Hundreds of miles of branch mains and pipes have been laid to mining districts, towns and farming districts, the most important being the Norseman extension of 101 miles. The system serves 54 towns and water is reticulated to 1,800,000 acres of farming lands. Total length of mains is 1,850 miles and the population served is 70,000. Total quantity of water pumped from Mundaring in 1955–56 was 3,044 million gallons. Total cost of the system to the end of 1955–56 was £10,007,050.

(ii) *South-West Scheme (Comprehensive).* The Commonwealth Government has agreed to assist a scheme which will be administered by the State Government, to extend water for agricultural areas and towns in the south-west of Western Australia. Twenty-three towns and over 4 million acres of agricultural country will benefit. The original

estimated cost of this scheme was £4,300,000 of which the Commonwealth Government agreed to contribute 50 per cent. The revised estimate in 1955 was £10 million. These estimates exclude the cost of the raising of Mundaring and Wellington Dams, the works of which form the headworks of the scheme and are financed solely by the State Government. The laying of 80 miles of 30-inch pipe between Wellington Dam and Narrogin was completed early in 1956, together with two electric pumping stations.

Output from these stations is approximately 2½ million gallons per day, but provision has been made in the stations to add further units bringing the maximum pumping capacity up to nearly 7 million gallons per day.

A new pumping station at Narrogin Dam is to be built soon and the 24 inch rising main from this station to Cuballing Service Tank of 2 million gallons capacity and approximately 6 miles long is now in course of construction.

The work of raising Mundaring Weir 32 feet in height, giving a total capacity of 55,460 acre feet, was completed in 1951 and preparations are well in hand for commencing work in the raising of Wellington Dam 50 feet in height, increasing storage to 149,860 acre feet capacity. The new electric pumping station at Mundaring, having an ultimate capacity of 16 million gallons per day, was opened in December, 1953.

(iii) *Rock Catchments.* An interesting feature of the State's conservation system is found in the Barbalin, Narembeen and Kondinin District Farming Land Schemes in the wheat belt, where extensive granite outcrops have been used as catchments. The rain is caught at the foot of the rocks, and pumped to tanks from which the water is reticulated to farms and to a number of small towns. For further particulars *see* Official Year Book No. 37, page 1135.

4. **Underground Water.**—Individual farmers, orchardists, market gardeners and others derive water from wells using windmills or, where power is available, pumps and motors are used to tap such supplies. The Department of Public Works has twelve hand-boring plants which are lent out to farmers to facilitate boring operations to an average depth of 150 feet, also eight power-boring plants which are hired to local authorities. The Department also contracts with private firms to bore for communal farm supplies. During the past 62 years 341 artesian and sub-artesian bores have been sunk, in 290 of which fresh or stock water was struck. The total daily flow of all recorded bores in Western Australia is 90,872,000 gallons, and the average depth at which water is struck is 791 feet. Maximum depth of any bore is 4,006 feet and minimum 21 feet. Outside the artesian and sub-artesian basins over 5,000 bores have been sunk for water supplies.

5. **Ord River Scheme.**—The Ord River in the north-west of Western Australia traverses a tropical area served with monsoonal rains of irregular incidence and quantity, varying from 20 inches in the south to 30 in the north. The hottest months (December to March) are also the months of highest rainfall. Communications and population are sparse. The Western Australian Government is considering a proposal to build a dam to conserve 2,000,000 acre feet of water, equipped with hydro-electric plant, which might supply irrigation water for an area of 100,000 acres, if investigations show that the climate and soil conditions are suitable for vegetables, tropical fruits and rice. The economic production of these and other crops, as well as the possible use of such irrigation areas for interim fattening of cattle, is being examined at the Kimberley Research Station on the Ord River.

§ 7. Tasmania.

1. **General.**—(i) *Rainfall.* Brief particulars of the rainfall pattern in Tasmania were given on page 1136 of Official Year Book No. 37. (*See also* Chapter II.—Physiography, p. 45 of this issue.)

(ii) *Main Purposes of Conservation and Utilization.* Owing to Tasmania's fortunate rainfall position, scarcity of water is not a serious problem in normal seasons. Conservation of water for hydro-electric generation is the predominant interest, and conservation for domestic and industrial purposes is more important than irrigation. Conservation of water on farms is not practised to the same extent as on the mainland, probably because running streams and good rainfall are on a more generous scale. Provision of artificial storages (apart from house tanks) is rare, but progressive landowners are beginning to take advantage of modern plant, such as bulldozers, to provide small excavated storages on their properties. Underground water is of poor quality, but a small quantity which has been exploited to a limited extent only by bores and windmills exists over an area in the Midlands. Geological conditions do not appear to favour the utilization of underground water except on a minor scale.

(iii) *Administration.* The State does not own all natural waters, and consequently the subject of water rights is a difficult one. The Mines Department has power to grant certain rights for mining operations, and the Hydro-Electric Commission must approve the abstraction of water from any stream or lake of potential value for power generation. Under the provisions of an Act passed in 1944, the Water, Sewerage and Drainage Board was constituted to consider the financial and technical practicability of all water supply schemes constructed by local authorities, other than the cities of Hobart and Launceston. Legislation was also enacted during 1952 empowering Local Authorities to take water from specific sources of supply and to construct waterworks. The Act does not cover irrigation, which is practised to a limited extent only by private interests. Provision has been made in the Act for the protection of riparian rights, but there is no general legislation for the control of water courses.

2. **Hydro-electricity.***—Tasmania depends entirely on water for power development. The Hydro Electric Commission, the authority controlling the generation of electricity in Tasmania, conducts a continuous survey of the water power resources of the State assisted by modern methods such as aerial photography and geophysical exploration.

Most of the water potential is located on the Central Plateau with an area of about 1,500 square miles at an altitude of from 2,000 to 4,000 feet and subject to rainfall of from 30 inches a year in the east to 80 inches on the western perimeter. On the plateau are a large number of lakes which provide the means for storage at low cost. These include Great Lake with an area of 58 square miles, Lake St. Clair and Lake Echo, each more than 12 square miles, and others of smaller area.

The Derwent River and its tributaries which flow south-easterly carry off by far the greater part of the water which falls on the plateau and these rivers are therefore the most abundant source of power. They have been the cheapest to develop to date and most of the existing generating stations are located on them.

The three main rivers running westerly from the plateau—the Arthur, Pieman and Gordon—have only a small portion of their catchment areas at high level, but they run through regions of high rainfall and their power potentials are considerable. However, because of inaccessibility and climate, development of these rivers may be rather expensive and has been deferred in favour of more convenient schemes.

Rivers draining from the plateau towards the north and north-west coast, including the Emu, Forth and Mersey, have small catchments at high levels and no natural storages.

Two other important water power sources, independent of the Central Plateau, are the South Esk River in the north and the Huon River in the south. A power station at Trevallyn, near Launceston, utilizes water from the South Esk. The Huon has a large low-level catchment in the high-rainfall area near the west coast. Storage could be provided on it at a reasonable cost and because of the proximity to Hobart of a future power station, it has considerable value for peak load development.

3. **Industrial.**—Three principal industrial schemes have been installed privately. Australian Newsprint Mills Ltd. pump approximately 6 million gallons a day from the Derwent River at Lawitta for the Boyer Mills. Associated Pulp and Paper Mills Ltd. pump several million gallons a day from the Emu River at Burnie, and Titan Products Pty. Ltd. reticulate water from Chasm Creek to their factory at Heybridge. In addition the State has constructed a regional water scheme to serve the Australian Aluminium Production Commission's plant at Bell Bay on the River Tamar and to supply several Municipalities with bulk water for domestic and industrial purposes.

A second regional water scheme draws water from the River Derwent at Lawitta to provide domestic and industrial supplies in five southern Municipalities. Potential sources capable of greater development without storage exist on the Derwent, South Esk, Huon, Lake, Mersey and Forth Rivers. There is also a great reserve of untapped permanent streams in the western half of the State which is largely unsettled. Diversion to the eastern side of the watersheds is not regarded as practicable.

4. **Irrigation.**—There are no State irrigation projects, but preliminary inquiries as to the possibility of establishing one in the Coal River Valley have been made. Legislation is contemplated to give a new Commission extensive powers for river control and for the design of irrigation projects. All systems operating are privately owned, and with one

* *See also* Chapter VIII.—Electric Power Generation and Distribution, p. 285.

exception (at Bushy Park) are single-farm units. At Bushy Park, a small system serves a group of properties. The larger proportion of the area under irrigation is watered by gravitational systems and the remainder comprises areas devoted to vegetables and served by municipal water supplies. Irrigation as practised in Tasmania, was applied in 1955–56 to 11,499 acres devoted to : hops (1,248 acres) ; fruit (605 acres) ; pastures (7,290 acres) ; green fodder, etc. (1,117 acres) ; and other crops (1,239 acres).

§ 8. Northern Territory.

1. **Climate and Topography.**—Some particulars of the climate and main topographical features of the Northern Territory were given on page 1138 of Official Year Book No. 37, and in this issue information on climatic conditions will be found in Chapter II.—Physiography, and a brief outline of contour and physical characteristics in Chapter V.—The Territories of Australia.

2. **Administration.**—Under the Control of Waters Ordinance 1938–1955 of the Northern Territory natural waters are vested in the Crown. Where a watercourse or lake forms a boundary of any land alienated by the Crown, the beds and banks are deemed to remain the property of the Crown (except in special cases) and diversion of water is prohibited except under conditions prescribed. There is a Water Use Branch in the Northern Territory Administration under the control of a Director. The functions of the Branch include systematic stream gauging, collection of data on surface and underground water supplies, planning of water use for irrigation and town water supplies, flood prevention and control.

3. **Underground Water.**—The marked seasonal rainfall over the whole of the Northern Territory is one of the basic factors affecting the pastoral industry which provides the bulk of the Territory's income. The inadequacy of surface water during the dry season underlines the importance of underground water supplies in the Territory where, most of the cattle population is dependent on underground supplies for three to five months each year.

Rainfall is one of the factors controlling cattle population but geological features, controlling both soils and the storage of underground water, are even more important. In the northern-most portion of the Territory, which receives from 25 to 60 inches of seasonal rainfall per year, surface water supplies are, in general, adequate for the pastoral industry. Despite this, however, this area has a comparatively low carrying capacity for cattle and the pastoral industry is concentrated more in inland areas where feed retains more nutritive value in the winter despite dry conditions.

South from this well-watered northern-most portion, the Territory becomes progressively drier, with annual average rainfall of only five inches at the margins of the Simpson Desert in the south-east corner. In the lighter rainfall areas, the search for potable underground water becomes exacting but, in general, the regions providing the best pastures--the Ord-Victoria Region, the Barkly Tablelands and smaller areas in the Alice Springs district—provide also sub-surface conditions suitable for the storage of water. This comes about largely because, in these areas, both pasture and water are related to flat lying or gently folded limestones or volcanics of Upper Pretellozoic or Cambrian age, overlying the basement of older, more tightly folded, metamorphic rocks and granites which crop out over wide areas within the Territory.

In the Ord-Victoria Region, probably the best grass lands overlie volcanic rocks and extend over some 10,000 square miles. Ground water is obtained in shallow bores averaging 70 to 80 feet in depth and producing small supplies which range up to 1,500 gallons per hour. For the most part, water is stored in joints, faults or cracks in the rocks although in places sub-artesian conditions pertain and, on the whole, selection of bore sites is difficult. There are also small sedimentary basins in the region, some of which yield sub-artesian, and in places artesian water and provide areas of good pastures.

The Barkly Tablelands, which extend into Western Queensland, overlie flat-lying limestone, sandstone and shale of the Barkly Basin. In most places, underground water is under pressure (sub-artesian) but no flowing bores are known. Sandstones and beds of limestone with fractures and solution cavities provide a number of aquifers within the Basin. The hydraulic surface (to which pressure water will rise in bores) ranges between 500 and 600 feet above sea level and adequate supplies for the watering of stock are available at depths ranging from 150 to 400 feet from the surface. The water from over 90 per cent.

of the bores is suitable for stock and over 50 per cent. of it is suitable for human consumption. Investigations by the Commonwealth Bureau of Mineral Resources indicate that underground water supplies will be more than sufficient for the future development of the pastoral industry on the Tablelands.

In 1955–56, some 1,006 equipped bores were recorded, comprising 801 on pastoral properties (69 provided by the Government by way of assistance to pastoralists), 165 established by the Government on stock routes, 22 on Native Affairs Settlements, 11 on mining fields, six for town water supplies and one maintained by the Postmaster-General's Department. Latest details of bores on pastoral properties in the various districts relate to 1952 and understate the present position. They are :—Alice Springs, 357 ; Barkly Tableland, 288 ; Victoria River Downs, 87 ; Total, 732.

The number of stock route bores, watering some 2,500 miles of stock routes, has increased by approximately 56 per cent. in the period 1947–56, and the present figure of 165 bores represents on the average approximately one per 15 miles.

Regional surveys by the Bureau of Mineral Resources and the Commonwealth Scientific and Industrial Research Organization from 1947 to 1955 have established the existence of the valuable Barkly Basin of 57,000 square miles in the eastern part of the Territory and extensions of the Gulf Basin in the north-western part.

4. **Irrigation.**—There are no large-scale water conservation projects in the Territory with the exception of the Manton Dam (12,700 acre feet), which serves Darwin with a reticulated supply. Hydrological investigations are being carried out by the Administration and a public company to determine the supply of water and the best methods of control and use in the potential rice growing areas of the Territory. Agricultural activity in the Territory is not extensive.

The Katherine River appears to offer irrigation potentialities on the levee soil below the township. The river passes through a gorge upstream under conditions which appear suitable for dam construction. The Administration and the Commonwealth Scientific and Industrial Research Organization are investigating the potentialities of the area for agricultural production.

A small area (225 acres) was irrigated in the year ended 31st March, 1956, mainly for growing fruit and vegetables. For particulars of potentialities *see* p. 1138 of Official Year Book No. 37.

§ 9. Papua and New Guinea.

1. **Rainfall.**—Rainfall in Papua and New Guinea varies considerably from approximately 250 inches near Lindenhafen (New Britain) and 231 inches at Kikori (Papua) to about 70 inches near Marienburg (New Guinea) and 40 inches at Port Moresby (Papua).

2. **General.**—For a general description of these territories *see* Chapter V.—The Territories of Australia, page 121, of this Year Book. Irrigation has not been developed on any organized basis owing to the availability of high rainfall and the nature of agricultural development.

The Territory of Papua and New Guinea is well served with large rivers deriving their water from heavy tropical rains and high mountains which rise to over 14,000 feet. However, complete data regarding water resources are not available.

The largest rivers in the Territory include the Fly (a description of which is given in Chapter XXVI. of Year Book No. 40), the Sepik (700 miles), the Ramu (450 miles), the Purari (300 miles) and the Markham (110 miles).

The main water conservation interest in New Guinea at present is the hydro-electric potential which is extensive. An outline of schemes at present in operation is given in the previous chapter.