CHAPTER 15

WATER RESOURCES

This chapter is divided into two major parts:—water resources in Australia, and the management of these resources. The former provides information on such topics as the geographic background to water resources, surface and groundwater supplies and use and the drainage divisions in Australia. The latter summarises Australian and State assessment and management of water resources.

For information concerning general, descriptive and historical matter *see* Year Book No. 37, pages 1096–1141 and Year Book No. 51, pages 228–31.

An article on droughts in Australia appeared in Year Book No. 54, pages 991–6.

Introduction

Rainfall, or the lack of it, is the most important single factor determining land use and rural production in Australia. The chapter Climate and Physical Geography of Australia contains details on geographical and climatic features that determine the Australian water pattern. Australia is the driest continent in the world. The scarcity of both surface and groundwater resources together with the low rates of precipitation, which restrict irrigation and other uses (quite apart from economic factors), has led to extensive programs to regulate supplies by construction of dams, reservoirs, large tanks and other storages.

Geographic background

General. Water resources are determined by rainfall, evaporation and physical features including soil, vegetation and geology. Chapter 2, Climate and Physical Geography of Australia, contains a detailed description of the climatic features of the country. A brief description of the landforms appears in Year Book No. 61, pages 25–27. In assessing Australia's water resources, dependability and quality of supply must be considered, as well as amount.

Topography. The major topographical feature affecting the rainfall and drainage patterns in Australia is the absence of high mountain barriers; features range from sloping tablelands and uplands along the east coast Main Divide through the low plain and marked depression in the interior to the Great Western Plateau.

Drainage. Only one-third of the Australian land mass drains directly to the ocean, mainly on the coastal side of the Main Divide and inland with the Murray-Darling system. With the exception of the latter, most rivers draining to the ocean are comparatively short and account for the majority of the country's average annual discharge.

The interior lowlands exhibit endoreic drainage patterns and surface drainage is totally absent from some arid areas of low relief.

Climate. Australia's large area (7.7 million square kilometres) and latitudinal range (3,700 kilometres) have resulted in climatic conditions ranging from the alpine to the tropical. Two-thirds of the continent is arid or semi-arid, although good rainfalls (over 800 mm annually) occur in the northern monsoonal belt under the influence of the Australian-Asian monsoon and along the eastern and southern highland regions under the influence of the great atmospheric depressions of the Southern Ocean. The effectiveness of the rainfall is greatly reduced by marked alternation of wet and dry seasons, unreliability from year to year, high temperatures and high potential evaporation.

Settlement. The availability of water resources controls, to a large degree, the possibility and density of settlement; these, in turn, influence the quality of the water through production and disposal of waste. Most early settlements were established on the basis of reliable surface water supplies and, as a result, Australia's population is concentrated along the coast, mainly in the comparatively fertile, well-watered east, south-east and far south-west.

As settlement spread into the dry inland grazing country, the value of reliable supplies of underground water was realised. Observations of the disappearance of large quantities of the rainfall precipitated on the coastal ranges of eastern Australia eventually led to the discovery of the Great Artesian Basin which has become a major asset to the pastoral industry.

For further information on the influence of water resources on the spread of settlement in Australia *see* Year Book No. 61, page 860.

Surface supplies

Distribution and volume. As described above, permanent rivers and streams flow in only a small part of the continent. The average annual discharge of Australian rivers has been assessed at 343 x 10^9 cubic metres, of which 157 x 10^9 cubic metres is measured discharge and the remainder is estimated. This is small in comparison with river flows on other continents. In addition, there is a pronounced concentration of runoff in the summer months in northern Australia while the southern part of the continent has a distinct, if somewhat less marked, winter maximum.

Variability of flow. Even in areas of high rainfall, large variability in flow means that, for local regional development, most streams must be regulated by surface storage. However, in many areas evaporation is so great that storage costs are high in terms of yield. Extreme floods also add greatly to the cost of water storage, because of the need for adequate spillway capacity.

Potential development. Some 85 per cent of all water used in Australia is surface water. This quantity is about 15 x 10^9 cubic metres a year and represents about 12 per cent of the possible usable surface water available in Australia; it does not include the amount diverted for hydro-electric power generation and other purposes which does not affect the quantity of water available. However, the great variability of river discharge, high evaporation and lack of sites for storage on many catchments limit potential development. As an indication of the severity of the problem, Australia's runoff is estimated at 13 per cent of rainfall compared with 40 per cent in North America and Europe, 36 per cent in South America and Asia and 24 per cent in Africa, with the complementary figure representing the evaporation and transpiration percentage. There is, however, considerable scope for greater efficiency in water use.

Groundwater supplies

Groundwater is more important than surface water in about 60 per cent of the country. Australia's estimated annual groundwater recharge is 72 x 10^9 cubic metres, and annual groundwater usage is estimated at about 2.5 x 10^9 cubic metres.

An indication of the variability in quality and quantity of Australia's groundwater resources is given in the map sheets accompanying the Australian Water Resources Council's publication, *Groundwater Resources of Australia (1975)*.

Groundwater is divided according to its occurrence in the three main classes of aquifer:

(i) *Shallow unconsolidated sediments* comprise alluvial sediments in river valleys, deltas and basins; aeolian (windblown) sediments which generally occur in coastal areas; and lacustrine (lake) sediments. These sediments are often highly permeable and porous. Permeability and porosity may vary markedly according to orientation. Unconsolidated aquifers of this group generally occur at depths of less than 150 m and are often readily accessible to sources of water for recharge. Marked seasonal variations in water level are common.

(ii) *Sedimentary rocks* are generally made up of consolidated sediments. The aquifers owe their porosity to small voids between the grains which are often well compacted and cemented. They often cover significant areas, being continuous and of appreciable thickness. Rock strata usually dip quite gently. Nevertheless, over the full extent of the larger sedimentary basins, aquifers may reach great depths. Areas where recharge takes place may be small in relation to the extent of the aquifers. Water quality in individual aquifers may be quite good and fairly uniform over large areas. Some sediments contain a number of permeable and impermeable layers, creating a vertical sequence of separate aquifers, and water quality may vary greatly between them.

(iii) *Fractured rocks* comprise hard igneous and metamorphosed rocks which have been subjected to disturbance and deformation. Aquifers resulting from the weathering of any rock type are also included in this group. Water is transmitted mainly through joints, bedding planes, faults, caverns, solution cavities and other spaces in the rock mass.

The quality of groundwater varies considerably and sources are subject to pollution in much the same way as surface supplies. Locally, groundwater has also been polluted by poor drilling techniques which allow contamination of fresh or lower salinity waters by more highly saline waters, and also by the discharge of industrial wastes into underground drainage bores. The Port Phillip Basin has the problem of discharge of industrial and domestic waste underground, and in the Western Port Basin there has been control of groundwater withdrawal since 1968 to prevent overdraft and saltwater intrusion.

An Australian School of Drilling has been established under the auspices of the National Training Council to improve the skills of the water drillers.

For further details on the sources of groundwater and a table of the principal water-bearing basins in Australia, *see* Year Book No. 61, pages 865–6. A map showing the extent of known artesian basins throughout Australia is shown on page 273 of Year Book No. 48.

Drainage divisions and the use of surface and groundwaters

Groundwater and surface water have, in the past, tended to be viewed as separate resources because of their modes of occurrence, assessment and development. They are complementary components of the hydrologic cycle and in any assessment of the water resources of a region are not necessarily additive.

To promote a unified approach, river basins or groups of river basins have been adopted as the primary units of assessment. The *Review of Australia's Water Resources* 1975 (Department of National Development and Energy, Australian Water Resources Council, Canberra) contains a summary of the 244 river basins grouped into twelve divisions, together with a map showing the divisions. (*See* below.)

The conjunctive approach to water resources, even to importing water from outside the region, generally makes more water available for use than would be the case with independent use of the various sources. Year Book No. 61, pages 867–8 contains details of the conjunctive use of surface and groundwaters.

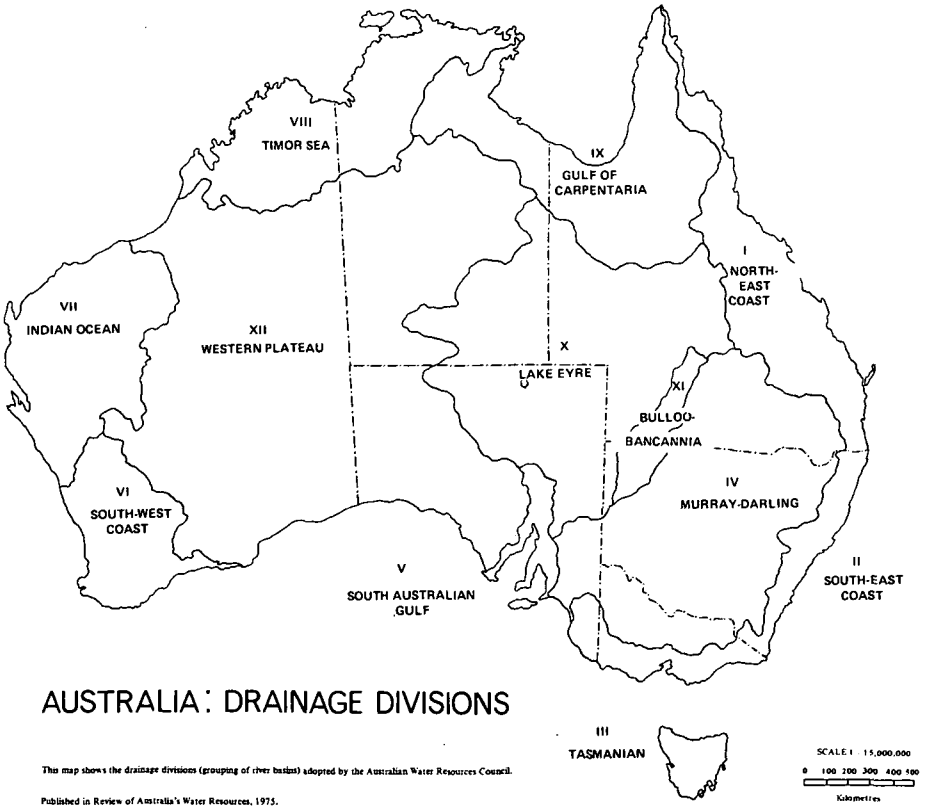

PLATE 38

In the *Review of Australia's Water Resources,* 1975 an attempt was made to assess the possible exploitable yield of surface water for each river basin (aggregating to Drainage Divisions) at the point of lowest practical downstream development, using the type of hydraulic structure considered technically feasible by the governments. These estimates take into account average annual flow, variability of flow, water quality and the availability of suitable sites for storage, but do not take into account economic factors.

AN ASSESSMENT OF THE POSSIBLE YIELD OF SURFACE WATER BY DRAINAGE DIVISION

(*Source:* Review of Australia's Water Resources, 1975)

Drainage division	*Adopted drainage area*	*Average annual discharge (a)*	*Possible exploitable yield*	*Estimated total yield of drainage area*	*Possible exploitable yield as percentage of total yield*
	mil. ha		mil. cu. m.		%
I North-East Coast	45	82,500	25,566	75,620	34
II South-East Coast	27	39,396	(*b*)15,992	37,499	43
III Tasmania	7	49,799	35,495	49,799	71
IV Murray-Darling	106	22,261	18,372	22,204	83
V South Australian Gulf	8	980	283	913	31
VI South-West Coast	31	7,290	1,841	4,935	37
VII Indian Ocean	52	4,160	490	3,815	13
VIII Timor Sea	55	74,260	16,423	74,260	22
IX Gulf of Carpentaria	64	58,230	10,094	49,180	21
X Lake Eyre	117	3,260	129	3,180	4
XI Bulloo-Bancannia	10	540	n.a.	540	n.a.
XII Western Plateau	246	—	—	—	—
Australia	**768**	**342,676**	**124,685**	**321,945**	**39**

(*a*) Includes fresh and marginal water but excludes brackish and saline water. (*b*) Includes a small amount of brackish water.

Groundwater is an important substitute for surface water in many parts of the country such as in the arid interior where the Great Artesian Basin provides the only reliable continuous supply of water for stock and domestic purposes. This Basin underlies 23 per cent of the continent and some 30,000 holes have been drilled, about 2,900 of which are still flowing. The high ratio of sodium to calcium and magnesium ions has an adverse effect on soil structure, rendering it impervious and generally unsuitable for irrigation.

Groundwater is increasing in importance as a source of water for irrigation, industry and domestic supply. There are many areas of intensive groundwater development which, although small, accounted for over a third of all groundwater withdrawals in 1975. The areas shown in the table below rely almost exclusively on groundwater from unconsolidated sediments.

Increasing use is made of conjunctive schemes, for example, where groundwater supplies are tapped to augment surface water or where, as in the Burdekin Delta, groundwater aquifers are artificially recharged during the summer wet season to enable water to be stored at low cost with negligible evaporation.

AREAS OF CONCENTRATED GROUNDWATER USAGE IN AUSTRALIA

(*Source:* Review of Australia's Water Resources, 1975)

Area	*Quantity*	*Use*
	mil. cu m/year	
Burdekin Delta (Queensland)	320	Irrigation of sugar cane
Namoi Valley (New South Wales)	108	Irrigation of small crops, including cotton
Condamine Valley (Queensland)	100	Irrigation of grain crops
Southeastern South Australia (*a*)	98	Irrigation, town supplies and industry
Bundaberg (Queensland)	94	Irrigation of sugar cane, industrial and domestic use
Lockyer Valley (Queensland)	70	Irrigation of small crops and fodder
Perth (Western Australia)	66	Irrigation of market gardens, domestic gardens and urban water supply
Hunter Valley (New South Wales)	53	Irrigation of small crops
Callide Valley (Queensland)	35	Irrigation of fodder and grain crops
Tomago Sands (New South Wales)	31	Urban water supply and industrial use
Pioneer Valley (Queensland)	31	Irrigation of sugar cane and domestic use
North Adelaide Plains (South Australia) (*a*)	21	Irrigation of market gardens
Botany Sands (New South Wales)	20	Industrial use
Sub-total	*1,047*	
Estimated total groundwater usage	**2,460**	

(*a*) Includes some water from limestone aquifers.

The first *National survey of water use in Australia*, published in 1981, gathered water use data on a national scale. The data provides a sound basis for the efficient utilisation of existing resources and for the planning of future projects. A summary of the results of the survey is given in the table below.

ESTIMATED ANNUAL WATER USE IN 1977 FOR AN AVERAGE CLIMATIC YEAR BY DRAINAGE DIVISION

(*Source*: The first *National survey of water use in Australia*; Department of National Development and Energy; Australian Water Resources Council, Occasional Papers Series No. 1; AGPS 1981)

Drainage division	*Surface waters (10^6M^3)*				*Ground waters (10^6M^3)*				*Totals (10^6M^3)*			
	Urban industrial	*Irrigation*	*Other rural*	*Total*	*Urban industrial*	*Irrigation*	*Other rural*	*Total*	*Urban industrial*	*Irrigation*	*Other rural*	*Total*
North-East Coast	388	473	-	861	40	670	-	710	427	1,210	126	1,770
South-East Coast	1,400	453	186	2,030	125	368	52	545	1,540	821	238	2,590
Tasmania	157	110	25	292	0.5	-	-	0.5	157	110	25	292
Murray-Darling	287	10,200	491	11,000	42	504	233	778	337	10,700	775	11,800
South Australian Gulf	37	24	10	70	9	63	7	79	222	88	29	339
South-West Coast	187	224	20	431	182	24	5	210	369	248	25	642
Indian Ocean	0.5	-	1	1	36	6	5	47	36	6	6	48
Timor Sea	14	67	6	87	15	0.5	10	25	29	68	19	115
Gulf of Carpentaria	20	2	-	22	15	0.5	1	16	35	2	37	73
Lake Eyre	2	1	2	5	10	1	5	16	13	1	43	57
Bulloo-Bancannia	-	-	-	-	-	-	-	-	1	-	3	4
Western Plateau	0.5	-	1	1	5	2	19	26	21	2	22	44

NB: Totals may not be the sum of the figures in any row or column as figures have been rounded, and water sources such as farm dams, not falling in the categories of surface or groundwater, have been included in the totals section.

Total water use (gross applied water) in Australia for 1977, adjusted for average climatic conditions, has been estimated at 17 800 x 10^6m^3 annually, corresponding to an overall total per capita use of about 3,500 litres per day. Of this total, approximately 74 per cent is for irrigation, 18 per cent is for urban/industrial uses and 8 per cent is for other rural water use. Withdrawals for hydro-electric power have not been included. In terms of sources for the water used, by far the largest proportion (about 84 per cent) of water is drawn from surface water sources. Groundwater sources, although of importance in some regions, account for only 14 per cent of the water used. A very small proportion, less than 0.5 per cent of water used is derived from artificial recharge or from reclaimed water. Sources for the remaining water used were not indicated and would include supplies from small bores, rainwater tanks, farm dams and the like. Of the total surface water withdrawals, 77 per cent are used for irrigation, 18 per cent for urban/industrial purposes and 5 per cent for other rural purposes. Corresponding figures for groundwater withdrawals are 67 per cent, 18 per cent and 14 per cent respectively.

Major dams and reservoirs

A map entitled *Australia—Dams and Storages*, published in 1975 by the Department of Minerals and Energy (now the Department of National Development and Energy), shows the location, height of dam wall, capacity and purpose of Australia's major dams and water storages. In the lists below, only dams with a gross reservoir capacity of more than 100 million cubic metres have been included. It should be noted that the Hume Reservoir lies on the New South Wales-Victoria border.

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA

Name and year of completion	*Location*	*Gross capacity (million cubic metres)(a)*	*Height of wall (metres) (b)*	*Purpose*
	NEW SOUTH WALES			
Eucumbene (1958)	Eucumbene River	4,807	116	Part of Snowy Mountains H/E Scheme
Hume (1936, 1961)	Murray River, near Albury	3,038	51	Irrigation, water supply, H/E
Warragamba (1960)	Warragamba River	2,057	137	Water supply for Sydney, H/E
Menindee Lakes (1960)	Darling River, near Menindee	1,794	18	Conservation, storage for Murray River Agreement
Burrendong (1967)	Macquarie River, near Wellington	1,677	76	Conservation, FC, water supply
Blowering (1968)	Tumut River	1,628	112	H/E, irrigation
Copeton (1976)	Gwydir River	1,364	113	Irrigation
Wyangala (1936, 1971)	Lachlan River	1,220	85	Irrigation, stock, etc.
Burrunjuck (1927, 1956)	Murrumbidgee River	1,026	79	Irrigation, H/E
Talbingo (1971)	Tumut River	921	162	H/E
Jindabyne (1967)	Snowy River	688	72	H/E
Lake Victoria (1928)	Murray River, near S.A. border	680	—	Conserves supplies for S.A.
Keepit (1960)	Namoi River, near Gunnedah	423	55	Conservation, irrigation, H/E
Glenbawn (1958)	Hunter River, near Scone	360	78	Conservation, irrigation, FC
Tantangara (1960)	Murrumbidgee River	254	45	H/E
Avon (1927)	Avon River	214	72	Water supply for Sydney
Lake Brewster (1952)	Lachlan River, near Hillston	150	-	Irrigation
Liddell (1968)	Gardiner Creek, near Muswellbrook	148	41	Cooling water for thermal electricity generation
Tallowa (1977)	Shoalhaven River, near Nowra	135	43	Water supply for Sydney
Googong (1978)	Queanbeyan River	125	59	Water supply for Canberra-Queanbeyan
	VICTORIA			
Dartmouth (1979)	Mitta Mitta River	4,000	180	Irrigation storage, H/E
Eildon (1927, 1955)	Upper Goulburn River	3,392	79	Irrigation, H/E
Waranga (1910)	Near Rushworth (Swamp)	411	12	Irrigation
Mokoan (1971)	Winton Swamp, near Benalla	365	10	Irrigation
Rocklands (1953)	Glenelg River	336	28	Domestic and stock water supply
Eppalock (1964)	Campaspe River	312	45	Irrigation, water supply
Cardinia (1973)	Cardinia Creek, near Emerald	287	79	Water supply for Melbourne
Upper Yarra (1957)	Yarra River	207	89	Water supply for Melbourne
Glenmaggie (1927, 1958)	Macalister River	190	37	Irrigation
Cairn Curran (1958)	Loddon River, near Newstead	149	44	Irrigation
Yarrawonga (1939)	Murray River	117	22	Irrigation
Toolondo (1952,1960)	Natural depression, near Horsham	107	-	Domestic and stock water supply
	QUEENSLAND			
Fairbairn (1972)	Nogoa River, central Qld	1,440	49	Irrigation, industrial
Somerset (1959)	Stanley River	893	50	Water supply for Brisbane, H/E
Fred Haigh (1975)	Kolan River, near Gin Gin	586	52	Irrigation
Ross River (1974)	Near Townsville	417	35	FC, water supply
Tinaroo Falls (1958)	Barron River	407	47	Irrigation, H/E
Glenlyon (1976)	Pike Creek, near Stanthorpe	261	62	Irrigation
Wuruma (1968)	Nogo River, near Eidsvold	194	46	Irrigation
Koombooloomba (1961)	Tully River	180	52	H/E, irrigation
Julius (1977)	Leichhardt River, near Mt Isa	127	35	Water supply, mining
Eungella (1969)	Broken River	131	46	Irrigation, industrial, mining, water supply
Beardmore (1972)	Balonne River	101	15	Irrigation, water supply
	WESTERN AUSTRALIA			
Lake Argyle (Ord) (1971)	Ord River, near Kununurra	5,720	99	Irrigation, FC, H/E
South Dandalup (1973)	Near Dwellingup	208	41	Water supply for Perth
Wellington (1933, 1944, 1960)	Collie River	185	37	Irrigation, water supply
Serpentine (1961)	Serpentine River	185	55	Water supply for Perth

For footnotes *see* end of table

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA—*continued*

Name and year of completion	*Location*	*Gross capacity (million cubic metres)(a)*	*Height of wall (metres) (b)*	*Purpose*
TASMANIA				
Lakes Gordon and Pedder (1974)—				
Gordon	South West	11,728	140	H/E
Scotts Peak			43	
Serpentine		2,963	38	
Edgar			17	
Miena (1967)	Great Lake	2,390	18	Storage for H/E
Lake St Clair (1938)	Central Plateau	2,000 (est.)	3	Natural storage for H/E
Mackintosh (1980)	Mackintosh River, near Queenstown	922	75	H/E
Tullibardine (1979)	Tullibardine River, near Queenstown		25	
Lake Echo (1956)	Lake Echo	725	19	H/E
Arthur's Lake (1965)	*Source of Lake River, near Great Lake*	571	17	H/E
Lake King William (Clark) (1949, 1966)	Derwent River	540	67	H/E
Devils Gate (1969)	Forth River, near Devonport	180	84	H/E
Rowallan (1967)	Mersey River	130	43	H/E
Cethana (1971)	Forth River, near Devonport	108	110	H/E
NORTHERN TERRITORY				
Darwin River (1972)	Darwin River	259	31	Water supply for Darwin

(*a*) Includes 'dead water', i.e., water below the operational outlet of the reservoir. (*b*) As a general rule, the figures shown for height of wall refer to the vertical distance measured from the lowest point of the general foundation to the crest of the dam, i.e., the level of the roadway or walkway on the dam.

ABBREVIATIONS: H/E—hydro-electricity, FC—Flood control and/or mitigation.

MAJOR DAMS AND RESERVOIRS UNDER CONSTRUCTION OR PROJECTED

Name	*Location*	*Gross capacity (million cubic metres)(a)*	*Height of wall (metres)(b)*	*Purpose*
UNDER CONSTRUCTION				
Wivenhoe	Brisbane River, near Fernvale, Qld	1,150	58	Water supply, FC, H/E
Thomson	Thomson River, near Erica, Vic.	1,110	160	Water supply, irrigation
Windamere	Cudgegong River, near Mudgee, N.S.W.	353	69	Irrigation
Glennies Creek	Hunter Valley, near Singleton, N.S.W.	284	67	Industrial, irrigation stock and domestic water supply
Awoonga High Dam	Boyne River, south of Gladstone, Qld.	255	46	Water supply, cooling water (power)
Boondooma	Boyne River, near Proston, Qld	212	50	Cooling water (power)
Blue Rock	Tanjil River, near Willow Grove, Vic.	200	75	Cooling water (power), domestic and industrial
Mangrove Creek	Mangrove Creek, near Gosford, N.S.W.	176	79	Water supply
PROJECTED				
Burdekin Falls Dam	Burdekin River, Qld	1,860	68	Irrigation
Lower Pieman	Pieman River, near Queenstown, Tas.	641	122	H/E
Split Rock	Manilla River, Namoi Valley, N.S.W.	370	64	Irrigation
Spencer	Denison Creek, near Nebo, Qld	127	24	Mining, water supply
Bjelke-Petersen	Barker Creek, near Murgon, Qld	125	33	Irrigation
Bastyan (Lake Rosebery)	Pieman River, near Queenstown, Tas.	125	75	H/E
Harding Dam	Harding River, W.A.	114	42	Water supply

For footnotes and abbreviations *see* previous table.

The following table summarises dams and storages existing and under construction in each drainage division according to purpose, capacity and regulated discharge. Three storages counted as mainly for hydro-electricity in the South-East Coast Division and eight in the Murray-Darling are part of the Snowy Mountains Hydro-electric Scheme which, as a whole, makes a major contribution to irrigation.

LARGE DAMS—NUMBERS EXISTING AND UNDER CONSTRUCTION

(*Source:* Review of Australia's Water Resources, 1975)

Drainage division(a)	*Total number*	*Main purpose*				*Total capacity*	*Regulated discharge*
		Irrigation	*Hydro-electricity*	*Water supply*	*Flood control, recreation*		
						mil. cu. m	mil. cu. m.
I North-East Coast	33	12	1	20	—	4,100	1,300
II South-East Coast	99	5	5	87	2	10,700	2,700
III Tasmania	43	1	31	11	—	19,500	8,700
IV Murray-Darling	104	34	15	53	2	20,700	10,500
V South Australian Gulf	24	—	—	23	1	240	150
VI South-West Coast	24	8	—	15	1	870	360
VII Indian Ocean	1	—	—	1	—	(*b*)	(*b*)
VIII Timor Sea	8	5	—	3	—	6,100	1,900
IX Gulf of Carpentaria	4	—	—	4	—	140	10
X Lake Eyre	2	1	—	1	—	(*b*)	(*b*)
Australia	**342**	**66**	**52**	**218**	**6**	**62,350**	**25,620**

(*a*) Divisions XI and XII are not represented. (*b*) Negligible.

NOTE: 1. Although most dams are used for water supply, the greatest volume of water is reserved for irrigation.
2. 'Total capacity' of storages is not the same as 'gross capacity' which includes an estimate for water below the operational outlet of the reservoir.

Water quality

Water quality is an important factor in determining the potential use of a particular water resource. Its management is essentially aimed at maintaining each resource in a condition suitable for the beneficial use or uses considered appropriate by the community.

Quality of water may be highly variable over time. Runoff resulting from rainfall may pick up a whole range of contaminants in passing over and through the soil; evaporation results in the concentration of these dissolved solids while, on the other hand, storm waters can dilute the concentration of pollutants. Water quality, while being generally related to the quantity of flow, may also vary with the depth and breadth of a body of water.

In the long term, land use changes generally affect the quality of groundwater where runoff enters aquifers. For example, the replacement of deep rooted trees in the south-west of Western Australia by shallow rooted grasses for agriculture has disturbed the natural water and salt balance, mobilising salt and increasing stream salinity. About 160,000 hectares of land have been rendered too saline for normal crops and pastures, while water quality in the Wellington Dam storage continues to deteriorate because of this saline inflow, affecting irrigation users downstream as well as urban communities in the Great Southern Towns Water Supply region which rely on this source for domestic water. Elsewhere, salination of non-irrigated land, particularly in Victoria, is increasing mainly as a result of land clearing, and water quality will deteriorate as saline runoff and seepage finds its way into streams.

Although some Australian rivers are naturally saline, the quality of surface water is generally good. However, most types of water pollution experienced in advanced industrial countries also occur in Australia. The main problems relate to sewage, industrial effluents and increasing salinity mainly caused by agricultural activities. In some parts of Australia untreated or inadequately-treated sewage and trade effluents are discharged into inland and coastal streams used for town water supplies. Mining activities cause pollution by the discharge of ore-processing wastes or mine water into streams or by leaching from waste dumps as happened in the Molonglo River in New South Wales where zinc was being leached from tailings and slime dumps at Captains Flat. Remedial work at Captains Flat was undertaken to prevent further erosion and leaching of the waste dumps, and to minimise the flow of mine water discharging through springs into the Molonglo River.

Water supplies to many towns and small settlements throughout Australia are of low quality and can at times fall short of the World Health Organisation standards for drinking water. In many cases, relief may be possible through small water treatment plants.

The increasing salinity of the Murray River in recent years is a source of concern as the river is vital for irrigation and domestic water and provides much of Adelaide's water supply. The problem is the

increasing amounts of saline surface and underground water discharged from irrigation areas, compounded by concentration through evaporation. This is in addition to the river's quite high natural salt load. Groundwater mounds have progressively built up under some irrigation areas to the point where the water table has reached the root zone in some irrigation areas causing reduced productivity and, where saline, complete barrenness. As the sedimentary beds of the river basin were laid down under a marine environment, the groundwater is generally saline and, when drainage does return to the river, it carries large amounts of salt. Salinity levels in the river, however, vary seasonally. During periods of low flow or when seepage from the saturated banks returns following prolonged floods, the concentration of salts may increase significantly, approaching the salt susceptability limits of some crops. Citrus growers in some areas are having to install under-tree sprinkler systems to prevent yield depression, defoliation and other tree damage caused by saline water from overhead sprinklers. Present control measures include the provision of evaporation basins for the disposal of highly saline drainage water and the regulation of river flow to control water quality by dilution.

Salinity control and drainage is expensive and requires a co-ordinated approach. New South Wales, Victoria and South Australia have commenced, and in some cases completed, urgent salt interception projects recommended as the first stage of a co-ordinated plan of action developed by consultants engaged by the Commonwealth and these three States. Work is continuing on medium term salt interception and drainage projects. These are being funded under the Commonwealth's National Water Resources Program. By the end of 1981–82 a total of $35 million had been spent on salinity and drainage projects in the Murray Valley on a dollar-for-dollar basis between the States and the Commonwealth Governments. In the longer term, a River Murray water quality management plan is required, embracing the co-ordinated operation of engineering works in three States, river regulation procedures including possible dilution flow releases, and water quality standards for the various reaches of the river. *The River Murray Commission,* under its new powers in relation to water quality, has engaged consultants to undertake a two-year study aimed at providing a firm technical base for an appropriate water quality management plan.

Water management

Australia's water resources are managed by about 800 irrigation authorities, metropolitan water boards, local government councils and private individuals. State authorities dominate the assessment and control of water resources as, under the Commonwealth Constitution, primary responsibility for management of water rests with the individual State governments. The Commonwealth Government is responsible for matters relating to its Territories, and participates indirectly through financial assistance or directly in the co-ordination or operation of interstate projects through bodies such as the River Murray Commission. In other instances where political boundaries intersect some river basins, co-operation between governments has been necessary to develop resources.

Australia's attitudes to water resources management have changed substantially over the last twenty years. Water management is no longer seen just in terms of storing water and regulating streams for consumptive use, but also in terms of conserving unregulated streams in an unmodified landscape for wild life preservation or recreation purposes or for possible social or economic use by future generations. In addition, agricultural, industrial and urban development has led to greater attention being paid to water quality management.

In October 1975, the Commonwealth and State governments adopted a statement setting out the basic principles and goals underlying a balanced approach to the development and management of water resources in Australia. *See* Year Book No. 63, page 340, for further details.

The development of water resources in the States has an important bearing on the Commonwealth's broad interests in economic management, resource allocation, foreign exchange earnings, distribution of income and related matters. Consequently, the Commonwealth has participated in water resource matters in the States in instances of mutual Commonwealth/States concern or in the national interest. Currently a $200 million, five year National Water Resources Program, which was announced by the Prime Minister in February 1978, is financially assisting the States in the development, management and assessment of their water resources.

In response to recommendations in a report of a Senate Inquiry into the Commonwealth's role in water resources matters, a Commonwealth Water Policy was announced in March 1979. In co-operation with the States the Commonwealth is seeking to achieve the long-term beneficial use of Australia's water resources. Briefly, the main policy thrusts appropriate to the Commonwealth for this purpose were seen to be:

- ensure, as far as practicable, that water resource difficulties do not constrain national development;

- minimise losses and disruption caused by floods;
- encourage management practices which reverse trends in the deterioration of water quality and associated land resources;
- encourage a comprehensive approach to water/land planning and management;
- encourage the efficient use of water resources;
- encourage the development of financial and cost allocation policies appropriate to changing economic circumstances and community values; and,
- encourage public awareness and involvement in water resource issues.

A number of key water issues relating to the development and management of Australia's water resources are already receiving close attention: others are expected to emerge in the near future. Some relate to water quality, including that resulting from irrigation-induced and dryland salinisation, specific and widespread sources of pollution in both urban and agricultural areas, aquatic weeds, levels of treatment for urban water supplies, and the cost and technology of water re-use.

Water resources readily accessible to centres of demand are already substantially committed, although there is a widespread recognition of the considerable scope which still exists for increased efficiency in the use of existing supplies. However, on a local or regional basis, the availability of adequate water supplies is becoming a key factor in continuing economic development. It appears inevitable that new supplies, in certain situations, will depend on the processing of water resources of marginal quality and waste water to acceptable standards for domestic and industrial use. In turn, this will generate pressures for the development of more advanced water treatment technologies.

Perspective on Water Resources to the Year 2000 Study

The Government has commenced a study to develop a perspective on Australia's water resources to the year 2000. The study will identify water resources development and management issues which have a potential for impeding national development.

A Steering Committee has been established to supervise the study which is being undertaken by the Department of National Development and Energy. A range of consultants' studies has also been commissioned to provide data for the committee.

The study is scheduled for completion by March 1983.

Research and continuing assessment of water resources

Australian Water Resources Council (AWRC)

A widening awareness of the need for a co-ordinated Australian approach to water utilisation led to the formation in 1962 of the Australian Water Resources Council by joint action of the Commonwealth and State governments. The Council comprises the Commonwealth and State Ministers primarily responsible for water resources, with the Commonwealth Minister for National Development and Energy as Chairman, and is serviced by a Standing Committee consisting mainly of the heads of Departments responsible to these Ministers, and by six permanent technical committees.

The objective of the Council is to provide a forum for exchange of views relating to the development of policies, guidelines and programs which may be considered appropriate to assist in the most beneficial and orderly assessment, development and management of Australia's water resources.

See Year Book No. 61, page 869 for further details on the work of the AWRC.

Water resources research

Comprehensive programs of research and investigation are being pursued by State water and agricultural authorities, the Commonwealth Scientific and Industrial Research Organization (CSIRO), the Bureau of Meteorology and the Australian Water Resources Council, often in collaboration. The Commonwealth Water Research Fund was established in 1968 to provide support for a research program developed through the Australian Water Resources Council. The Fund is administered by the Department of National Development and Energy. The program covers fundamental and applied research into all aspects of water resources with the aim of providing a better basis for the assessment, planning, development and management of Australia's water resources. It complements research work being carried out by the government agencies, universities and other organisations and, in general, is used to stimulate new work not handled within existing programs. The program for the current 1980–83 program is diverse with emphasis on floodplain management, water storage management, nonpoint sources of pollution, salinity, waste disposal and reuse, drinking water quality, aquatic biology, groundwater, evapotranspiration and new instruments and techniques.

Water research by the CSIRO can be grouped under the following broad headings:

Water resource management. The aims of programs in this area are to develop ecologically sound methods for the management of irrigation water distribution systems and associated surface waters and to develop integrated methods of managing aquatic plants.

Groundwater research. The physical and chemical processes affecting the quantity and quality of groundwater are being investigated. Included are studies of natural interactions between surface water, groundwater, soils and rocks, and responses to man-made factors such as mining, waste disposal, agriculture, artificial recharge and pumpage.

Land management for water resources. Included in this area are studies of the processes involved in the movement of chemical pollutants and soluble salts from land to water resources, research into methods for controlling the quality of water resources by manipulating land and vegetation, investigations of processes involved in the recharge of water-table aquifers, and an analysis of the decision-making process in the management of land and water resources.

Hydrology and climatology. The objectives of research in this area are to advance the knowledge and basic understanding of hydrologic and climatic systems and processes and to develop better methods of collecting and presenting information about water resources and climate and assessing their use potential and limitations. In addition, the application of soil physics theory on movement of water in soils is being extended to the scale of landscape units and catchments.

Water and wastewater purification. A variety of projects are underway in this area, including the development of low-cost, energy-saving procedures for treating and recycling wastewater; the development of more effective processes for the removal of turbidity and colour from water, and for sludge disposal; and improvements in sewage treatment processes and the upgrading of effluents to the standard required for large-scale use.

Research is also concentrating on the simplification of continuous ion-exchange processes such as dealkalization, softening and desalination by the use of magnetic resins and adsorbents; the improvement of Sirotherm resins used in desalination operations; and studies of the surface chemistry of magnetite and natural colloids used in magnetic processes for the purification of water and wastewaters.

Investigations are also being undertaken to examine the levels, influence and methods of removal of nitrogen, phosphorus and non-biodegradable compounds in wastewaters and to protect the receiving waters for beneficial uses.

Review of water research in Australia

During the latter part of 1981 and the first half of 1982, the need to upgrade water research in Australia was examined in separate reports by the Commonwealth/States working group of the Australian Water Resources Council, CSIRO and the Bureau of Mineral Resources. In May 1982, CSIRO announced organisational changes to provide more appropriate focus for water research within the organisation. More recently (August 1982), following a close examination of the various reports, the Government announced its decision to establish a National Water Research Council and arrangements for improving the co-ordination of research within Commonwealth research agencies. The council, supported by the Commonwealth Department of National Development and Energy, will provide advice to the Government on research needs, priorities and programs.

International aspects

International water organisations

Australia liaises with international bodies and United Nations agencies concerned with water resources and participates in their activities in various ways.

Organisation for Economic Co-operation and Development (OECD). Australia's membership of the OECD since 1970 has involved participation in the work of Water Management Group which investigates and rationalises problems which are the subject of international concern, and develops strategies—economic, legal and technical—which might resolve them.

United Nations Educational, Scientific and Cultural Organization (UNESCO). The International Hydrological Decade (IHD) (1965–1974) was a period in which participating countries implemented an international program designed to advance the science and practice of hydrology. Following the conclusion of the IHD, an International Hydrology Program (IHP) was commenced and an Australian UNESCO Committee for the IHP (AUCIHP) was formed to co-ordinate Australian input to the IHP.

World Meteorological Organization (WMO). Through its Commission for Hydrology, WMO is the specialised UN agency dealing with operational hydrology—the measurement of basic hydrological elements, water resources assessment and hydrological forecasting. WMO has an Operational Hydrology Program (OHP) which is co-ordinated with and complemented by UNESCO's IHP. Within the OHP is the Hydrological Operational Multipurpose Subprogram (HOMS) involving the organised transfer of hydrological technology among members. Australia is a contributor to HOMS and has established a HOMS National Reference Centre within the Secretariat of the Australian Water Resources Council (AWRC). In Australia, hydrological and meteorological activities relative to water resources are co-ordinated by the AWRC for the Permanent Representative of WMO in Australia, the Director of Meteorology.

Economic and Social Commission for Asia and the Pacific (ESCAP). This Commission, through its committee on Natural Resources, reports on water policy issues in addition to other activities. By participation in this conference and in seminars arranged on selected topics, Australia contributes to, and benefits from, identification of the main problems of water resources management in a densely populated, developing region.

United Nations Environment Program (UNEP). Australia participates in a world registry of major rivers covering discharge and pollutants and of clean rivers so defined and in the development of methodology for analysis and planning of water resources management.

World Health Organisation (WHO). Australia is participating in the water quality monitoring component of the WHO Global Environmental Monitoring System (GEMS) which will provide a consistent global overview of changes in water quality.

National and interstate agreements

In the section on *Water Management* above, reference was made to the responsibilities of government on the national, state and local authority levels. In this section, some additional details are provided on their roles in the management of water resources.

The Murray-Darling Drainage Division's surface water resources are the most highly developed in Australia, with 91 per cent of the possible exploitable yield currently committed for use. The Division contains the continent's largest river system which can be divided into three main groups of rivers:

(a) the Darling River and its tributaries;
(b) the Murrumbidgee River and its tributaries; and
(c) the Murray River and its tributaries upstream from the confluence of the Murrumbidgee and the Murray.

The river basins that comprise the area under the control of the River Murray Commission are the nine basins in group (c) above and the three basins adjacent to the lower reaches of the Murray.

River Murray Waters Agreement

The *River Murray Waters Act* 1915 ratified an Agreement between the Commonwealth and the States of New South Wales, Victoria and South Australia. The Commonwealth Department of National Development and Energy is responsible for the Commonwealth's interest under the Act. Year Books prior to No. 39 contain a number of summaries of the historical events leading to the Agreement of 1914 which provided for a minimum quantity of water to pass to South Australia. Further details on the River Murray Waters Agreement and subsequent amendments may be found in Year Book No. 61, pages 870–2.

The River Murray Commission, established in 1917 to give effect to the Agreement and representative of each of the four Governments, is responsible for the management of the flow of water in the River Murray, the construction, maintenance and operation of storages and other regulatory works to make water available for irrigation, navigation, and urban purposes; and for the allocation of water between the three States. Dartmouth Dam—a major project of the River Murray Commission and the fourth largest water storage in Australia, was completed in November 1979. The reservoir has been storing water since November 1977.

Dartmouth and Hume Reservoirs together with Lake Victoria and the Menindee Lakes storages, are the key storages operated by the River Murray Commission to regulate the River Murray system. A series of weirs along the river provide for irrigation diversions by the three States. The major diversion weir is at Yarrawonga. A number of the weirs have locks to enable navigation of the river to be maintained.

Towards the end of 1976, the four Governments agreed that the River Murray Commission should assume the function of co-ordinating water quality and quantity management of the River Murray to the extent of taking account of water quality in its operations and investigations, monitoring the quality

of the river, and being authorised to make representations to the Contracting States on water quality issues. The Governments agreed to give the Commission interim authority in this regard pending the necessary legislative action and formal amendment of the Agreement.

A preliminary draft substitute Agreement prepared by the Commission in 1978 was accepted in principle by the four Governments as a basis for negotiations on a new Agreement. A major review of the Agreement (the first since 1914) was carried out in 1981 and endorsed by the four Governments. The review has proposed the expansion of the responsibilities of the River Murray Commission to include water quality in addition to water quantity in the main stem of the river and associated storages. The Commission has been authorised to operate within the terms of the new Agreement pending its ratification by legislation in the State and Commonwealth parliaments.

New South Wales–Queensland Border Rivers Agreement

This agreement came into effect in July 1947 and provided for the construction of a dam and several weirs on the rivers which constitute part of the boundary between the two States. This Act was amended in November 1968 to provide for storages on Pike Creek (Queensland) and the Mole River (New South Wales) and construction of further weirs on the Border Rivers and regulators on effluents of the Border Rivers and works for improvement of flow in streams which intersect the Queensland-New South Wales border west of Mungindi.

Glenlyon Dam on Pike Creek with a storage capacity of 261 million cubic metres was completed in 1976 and seven regulators on the Balonne-Culgoa River System have been constructed.

The Dumaresq-Barwon Border Rivers Commission, constituted of representatives of both States, administers the Agreement and the sharing of water.

Snowy Mountains Hydro-electric Scheme

This scheme was set up in 1949 by the Snowy Mountains Hydro-electric Power Act. Its prime purpose was to generate large quantities of peak load power and, by diverting the southern-flowing Snowy River through trans-mountain tunnels, to augment the flow of the Murray and Murrumbidgee Rivers to permit continuing expansion of irrigation in the fertile river plains. All storage works are now completed.

Details of the diversions and associated power works, together with details of construction, are given in Chapter 18, Energy.

The Snowy Mountains Council, constituted of representatives of the Governments of the Commonwealth, New South Wales, Victoria and the Snowy Mountains Hydro-Electric Authority, administers the operation of the Scheme, including the timing and amounts of electricity generation and water releases.

States and Territories

The foregoing text deals with water conservation and irrigation in Australia generally and with international, national and interstate aspects. The following survey covers the local pattern of water resources and the steps taken by the State Governments to bring about their development. In the various States, water policies 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 the management of irrigation water supplies is an area of major emphasis, with approximately two thirds of a million hectares under irrigation. In Queensland, up to the present, the predominant emphasis has fallen on water (mainly underground sources) for stock and the development of small irrigation schemes in sub-humid and humid areas, principally to stabilise production of such crops as tobacco, sugar, cotton and pastures. 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 relates almost exclusively to hydro-electric generation. The Northern Territory is concerned primarily with water supplies for population centres and mining and pastoral industries.

New South Wales

Administration

The Water Resources Commission, New South Wales, is a Statutory Authority formed in 1976 by a reconstitution of the Water Conservation and Irrigation Commission. Administrative authority is vested in the Chief Commissioner, who is assisted by two full-time Commissioners and two part-time

Commissioners. All five are appointed by the Governor. The operations of the Commission cover water conservation, control of irrigation areas, the 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. An important function of the Commission is planning for the co-ordinated development and allocation of the State's water resources. This entails the assessment and projection of demand for all purposes and also involves the quantitative and qualitative assessment of the available resources. Another important planning function relates to flood plain management. The Water Resources Commission Act, 1976, has widened the initiatives which the Commission is able to take in the fields of flood plain management and flood mitigation management. The search for, and surveillance of, groundwater for water supply is another important planning activity.

Under the Water Act, 1912 (as amended) 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 399 of this chapter.

Schemes summarised

The bulk of irrigated land is along the Murray and its tributary, the Murrumbidgee, regulated by the Hume, Blowering and Burrinjuck dams. Smaller areas are served by the Wyangala Dam, Lake Cargelligo and Lake Brewster on the Lachlan (a tributary of the Murrumbidgee), by Glenbawn Dam on the Hunter River, by Keepit Dam on the Namoi River, by Burrendong Dam on the Macquarie River, by the Menindee Lakes Storage on the Darling River, by Copeton Dam on the Gwydir River and by Chaffey Dam on the Peel River. None of the other rivers are regulated by large head storages, though weirs and dams have been provided for town supplies, etc. in many places. In addition 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 nine irrigation areas, although two of these, Yanco and Mirrool, are generally described under the one heading, namely, the Murrumbidgee Irrigation Area. Others are: Coomealla, Curlwaa, Hay, Tullakool, Buronga, Mallee Cliffs and Coleambally.

A detailed description of the Murrumbidgee Irrigation Area is contained in Year Book No. 61, pages 875–7. The Water Resources Commission controls land transactions and water supplies for the MIA, but has no jurisdiction over land transactions in neighbouring irrigation districts (although it is responsible for the operation and maintenance of the water supply in these areas). The other irrigation areas follow the same administrative pattern as the MIA.

Irrigation districts are set up under the Water Act, 1912 (as amended) for (*a*) domestic and stock water supply and (*b*) irrigation. The essential difference between an 'Area' and a 'District' is that, in the case of the former, all the land to be included in the Area is acquired by the Crown and then sub-divided into separate holdings. Within the District, however, existing ownership of land is not disturbed other than to acquire land required for water distribution works. Since the completion of the Hume Reservoir, several such districts have been established along the Murray to utilise the New South Wales share of the Storage. 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 will be irrigated, but additional water, when available, may be obtained by landholders. 'Water right' is the annual quantity that will cover 1 hectare to a depth of 100 mm.

The Water Act, 1912 (as amended) provides for the constitution of Trust Districts for domestic and stock water and irrigation, and empowers the Commission to construct, acquire or utilise 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.

Irrigation Trusts are established under the same Act and are administered by trustees in a similar way. There are seven of these trusts.

The Lowbidgee Flood Control and Irrigation District, 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. Another district, Medgun, near Moree in the north-west, is also in operation.

CROPS AND PASTURES IRRIGATED, BY METHOD OF IRRIGATION, NEW SOUTH WALES 1980–81

(Hectares)

	Method				
Crops and Pastures	*Sprays*	*Furrows and/or Flood*	*Trickle*	*Other and multiple methods*	*Total*
Pure Lucerne	22,136	8,743	n.a.	677	31,556
Other pastures (sown or native)	43,944	224,109	n.a.	10,928	278,981
Wheat	11,464	125,024	n.a.	3,265	139,753
Other cereals for all purposes	14,471	138,940	n.a.	3,005	156,416
Vegetables for human consumption	8,495	2,191	72	270	11,028
Citrus fruit	4,290	3,658	249	396	8,593
Other fruit	2,299	1,260	1,982	563	6,104
Grapevines	1,342	6,414	1,244	45	9,045
All other crops	5,588	66,246	72	1,222	73,128
Total	**114,029**	**576,585**	**3,619**	**20,371**	**714,604**

SOURCES OF IRRIGATION WATER, NEW SOUTH WALES 1980–81

Source of supply	*Area irrigated*	*Percentage of total area irrigated*
	(hectares)	%
Surface water		
from State irrigation schemes	414,298	58
from other schemes (including private group schemes)—		
from rivers, creeks, lakes, etc. (*a*)	228,508	32
from farm dams	20,033	3
Total surface water	*662,839*	*93*
Underground water supply (e.g. bore, spear, well) (*b*)	48,882	7
Town or country reticulated water supply	2,883	—
Total all water sources	**714,604**	**100**

(*a*) Includes regulated and unregulated streams. (*b*) Naturally or artificially replenished.

Future program

The program of development in hand includes the provision of additional dams, weirs, flood mitigation and drainage schemes and river management works.

Construction work continued on Glennies Creek Dam in the Hunter Valley, Windamere Dam on the Cudgegong River, Hay Weir on the Murrumbidgee River and a weir on the Darling River near Bourke.

The construction of surface and sub-surface drainage schemes continued in the Murray Valley to alleviate rising groundwater and salinity problems.

Feasibility and environmental assessments have been completed for the enlargement of Glenbawn Dam on the Hunter River.

Investigations are continually being carried out to assess demand and identify worthwhile projects which could be implemented as funds become available. Projects investigated include the inland diversion of coastal rivers and additional major dams in the Hunter Valley.

A comprehensive State Water Plan is being prepared. The Plan is intended to provide a broad framework for the efficient management and orderly development of the State's water and related land resources.

For more detailed information on Water Resources in New South Wales see the chapter entitled *Physical Development* in the latest edition of the New South Wales Official Year Book.

Victoria

Administration

Victorian Governments have been active in the development of country water supplies since the 1860's when major works to supply the Bendigo goldfields were undertaken. Local trusts to construct and operate waterworks under Government supervision were provided for in the *Water Conservation Act 1881*. Development under the trust system was greatly stimulated by the *Irrigation Act 1886*, which provided for the construction of national headworks by the State, and vested in the Crown the right to the use and control of all surface waters. By 1900 there were 33 irrigation trusts and 18 other rural water supply trusts, but the system of local control was then breaking down under financial difficulties.

The *Water Act 1905* established the State Rivers and Water Supply Commission to take over the Irrigation Trust districts (except the still-existing First Mildura Irrigation Trust) and to exercise the State's functions in the further control and development of surface waters outside the metropolis. The Commission now supervises all private diversions from streams and directly administers irrigation districts, rural waterworks and urban districts, flood protection districts and urban water supplies. It also supervises the activities of local urban water supply authorities, and local sewerage, river improvement and drainage authorities.

Works summarised

The State Rivers and Water Supply Commission's storages are augmented by Victoria's half share in River Murray Commission storages. Most of the water is for irrigation. However, about one quarter of irrigation production is from lands irrigated by 'private diverters', i.e., irrigators who are authorised to take water from streams, lakes, etc., but who do not come within the boundaries of an irrigation district.

Rural water supply systems

The principal irrigation systems in Victoria are:

- *Goulburn–Campaspe–Loddon.* The main storage is Lake Eildon with a capacity of 3,392 million cubic metres. The main products in these systems are dairy products, fruit, wool and fat lambs. Annual production of deciduous canning fruits in the eastern part of the system is about two-thirds of Australia's total.
- *Murray River System.* The Murray Valley Irrigation Area and the Torrumbarry Irrigation System are irrigated by water diverted at the Yarrawonga and Torrumbarry Weirs respectively. These areas are devoted mainly to dairying, fat lambs and canning fruit (Murray Valley) and dairying, fat lambs, vineyards, orchards and market gardens (Swan Hill). Downstream from Swan Hill, the First Mildura Irrigation Trust and four Commission Districts are supplied by pumping and produce mainly dried vine fruit, citrus fruits, and table and wine grapes.
- *Southern Systems.* The Maffra–Sale–Central Gippsland district, supplied from the Macalister River and regulated by Lake Glenmaggie, is devoted mainly to dairying.
- *Werribee and Bacchus Marsh.* These districts produce fresh fruit, vegetables and dairy products mainly for the local domestic market. Irrigation is supplied from the Werribee River system which is regulated by three main storages, viz. Pykes Creek, Melton Reservoir and Lake Merrimu.
- *Wimmera–Mallee Domestic and Stock Supply System.* Storages in the Grampian Ranges ensure farm water supplies over the riverless pastoral and cereal lands to the Murray. Without this supply, occupation of the region would be extremely hazardous. There are small areas of irrigation supplied from this system near Horsham and Murtoa.

CROPS AND PASTURES IRRIGATED, BY METHOD OF IRRIGATION, VICTORIA 1980–81

(Hectares)

Crops and Pastures	Method				Total
	Sprays	Furrows and/or Flood	Trickle	Other and multiple methods	
Pure Lucerne	3,305	4,737	n.a.	147	8,189
Other pastures (sown or native)	36,423	406,369	n.a.	7,910	450,702
Cereals for all purposes	2,573	29,893	n.a.	299	32,765
Tobacco	2,026	22	n.a.	87	2,135
Vegetables for human consumption	15,649	2,903	30	1,350	19,932
Fruit	5,730	5,035	2,020	699	13,484
Grapevines	3,290	11,555	380	143	15,368
All other crops	1,614	2,318	31	35	3,998
Total	**70,610**	**462,832**	**2,461**	**10,670**	**546,573**

SOURCES OF IRRIGATION WATER, VICTORIA 1980–81

Source of supply	Area irrigated	Percentage of total area irrigated
	(hectares)	%
Surface water		
from State irrigation schemes	439,656	80
from other schemes (including private group schemes)—		
from rivers, creeks, lakes, etc. (*a*)	55,848	10
from farm dams	25,223	5
Total surface water	*520,727*	*95*
Underground water supply (e.g. bore, spear, well) (*b*)	14,814	3
Town or country reticulated water supply	11,032	2
Total all water sources	**546,573**	**100**

(*a*) Includes regulated and unregulated streams. (*b*) Naturally or artificially replenished.

Future Programs

The Victorian Water Commission's program of capital works continues to emphasise an increasing proportion of expenditure on urban water services, including waste water treatment and disposal, water quality and works to protect the water environment from the adverse effects of land and water use.

The program also reflects national policy in budgetary constraints on works programs in the public sector, and an increasing requirement for justifiable economic viability.

Major provisions in the program include—

- the continuation of a construction program of major water conservation dams for urban, industrial and irrigation supply;
- construction of further within-system storage in the Bendigo area and development of proposals to augment supply to Geelong;
- the construction of large trunk pipelines to augment supply to and to enhance the operating capabilities of the Mornington Peninsula water supply system;
- further development of country water supply and sewerage facilities;
- continuation of works to divert salt from drainage flows in the Kerang Region to evaporative areas;
- the continuation of surface drainage programs in the Northern Irrigation Districts.

For more detailed information on Water Resources in Victoria see the chapter entitled *Water Resources and Sewerage* in the latest edition of the Victoria Year Book.

Queensland

Administration

The important primary industries of Queensland are subject to relatively frequent and serious losses by either drought or extensive flooding.

The right to the use and flow and to the control of water in watercourses, lakes, springs and artesian wells is vested in the Crown, and the Commissioner of Water Resources is authorised to take measures to conserve water and provide for its more equal distribution and beneficial use. Under the *Water Resources Administration Act 1978–1981*, he is required to (*a*) prepare a complete description of the natural water resources of the State, both surface and underground, (*b*) make and keep a record of all the natural water resources of the State, both surface and underground, (*c*) evaluate the present and future water requirements in the State, (*d*) plan the development of the water of the State, (*e*) take such steps as he thinks fit to protect the water resources of the State from anything detrimental to their quality or that results in or is likely to result in a diminution in their quantity, (*f*) investigate and survey any natural water resource, surface or underground, (*g*) co-ordinate the investigation, evaluation and development of plans for control of flood waters and mitigation of flood damage, (*h*) construct works for the conservation, replenishment, utilisation or distribution of the waters of the State, (*i*) manage water conservation, water supply and irrigation undertakings established under any Act of the State. As required under the *Water Act 1926–1981*, and the *Irrigation Act 1922–1979*, rights to underground and surface water are allocated and their use is controlled by a system of licensing of all artesian bores and sub-artesian bores in areas proclaimed by the Governor in Council and all conservation and use (other than for stock and domestic supplies) of flow in watercourses. The Commission is required to control use to share supplies as equitably as possible in periods of shortage of supply.

The Commissioner is required to prepare a co-ordinated program of work for the conservation, utilisation and distribution of water resources, and to make recommendations to the Government regarding the carrying out of works in this program. He is principally responsible for water conservation and supply works for rural purposes, including irrigation, stock and domestic supply. In planning such storages, economies to all users are accrued by providing, where possible, for dual or multi-purpose use of works for irrigation, rural, urban and industrial uses including power generation and mining purposes.

Summary of schemes

Unlike other States, the greater part of the area irrigated in Queensland is by individual private pumping plants taking supply from streams or underground sources, spread widely through the State, rather than in constituted irrigation areas where supply is provided by channel systems delivering water to farms. Because of the predominance of irrigation by private diversion pumping, most of the storages are used to release water downstream to maintain supplies for such purposes.

CROPS AND PASTURES IRRIGATED, BY METHOD OF IRRIGATION, QUEENSLAND 1980–81
(Hectares)

	Method				
Crops and Pastures	*Sprays*	*Furrows and/or Flood*	*Trickle*	*Other and multiple methods*	*Total*
Pure Lucerne	13,550	111	n.a.	359	14,020
Other pastures (sown or native)	15,437	3,303	n.a.	944	19,684
Grain Sorghum	7,393	10,003	n.a.	689	18,085
Other cereals for all purposes	14,939	14,791	n.a.	1,640	31,370
Sugar cane	49,819	42,000	354	9,542	101,715
Cotton	1,104	18,984	n.a.	640	20,728
Tobacco	3,181	54	n.p.	54	3,293
Vegetables for human consumption	15,357	2,605	554	940	19,456
Fruit	4,990	223	1,817	652	7,682
Grapevines	237	12	83	13	345
All other crops	9,836	8,453	13	1,027	19,329
Total	**135,843**	**100,539**	**2,825**	**16,500**	**255,707**

SOURCES OF IRRIGATION WATER, QUEENSLAND 1980–81

Source of supply	*Area irrigated*	*Percentage of total area irrigated*
	(hectares)	%
Surface water		
from State irrigation schemes	52,923	21
from other schemes (including private group schemes)—		
from rivers, creeks, lakes, etc. (*a*)	51,082	20
from farm dams	21,934	9
Total surface water	*125,939*	*49*
Underground water supply (e.g. bore, spear, well) (*b*)	129,398	51
Town or country reticulated water supply	370	..
Total all water sources	**255,707**	**100**

(*a*) Includes regulated and unregulated streams. (*b*) Naturally or artificially replenished.

Irrigation areas

About 25 per cent of the area under irrigation annually, ie some 64,120 hectares, is concentrated in seven Irrigation Areas constituted under the *Irrigation Act* 1922–1979, where the supply is generally reticulated by channel systems (by means of gravity or by pumping) from the storage. In addition, some supply is also provided from streams regulated by the storage. A summary is set out on next page; further details are shown on page 883 of Year Book No. 61.

Irrigation areas	*Comments*
Dawson Valley	Around Theodore on Dawson River; cotton, graincrops and urban usage in Theodore and Moura.
Burdekin River	Complex system of conservation, irrigation, industrial and other uses; sugar cane, rice, seed and small crops; artificial recharging of underground water supplies from unregulated flows (Burdekin River)
Mareeba-Dimbulah	Hinterland of Cairns; tobacco, rice, peanuts and urban/hydro-electric uses; Tinaroo Falls Dam.
St George	Balonne River; cotton, soya beans and cereals, and urban uses; Beardmore Dam.
Emerald	Joint Federal-State undertaking based on State's largest storage—Fairbairn Dam; industrial and urban use, irrigation of cotton, soya beans and cereals.
Bundaberg	Joint Federal-State undertaking; sugar, tobacco and small crops and urban supplies for Bundaberg and adjacent shires; Fred Haigh Dam.
Eton	Hinterland of Mackay; sugar cane and water supply in Mackay area; Kinchant Dam.

A number of other schemes have been established under the *Water Act* 1926–1981, where water from storage is released downstream to maintain adequate supplies for pumping under licence to adjacent lands. Details on these and others currently under construction are in Year Book No. 61, pages 883–4.

Rural, stock and domestic supplies

Improvements to stock and domestic water supplies are assisted by Rural Water Supply Schemes and Bore Water Supply Areas (constituted under the Water Act). Investigation, design and administration of these schemes are carried out by the Queensland Water Resources Commission.

Underground water supplies

The availability of underground water, particularly the Great Artesian Basin, has played a major part in the development of the pastoral industry in Queensland. Underground water is also used extensively for irrigation on individual farms, particularly along the coastal fringe, and for domestic

purposes. Over half the area irrigated in Queensland receives its supplies from underground sources. In accordance with the requirements of the *Water Resources Administration Act* 1978–1981 the investigation of availability of underground water is being pursued by geological mapping, investigation drilling and hydro-geological assessment. The most important areas where water from this source is used for irrigation are the Burdekin Delta, Condamine Valley, Bundaberg, Lockyer Valley, Callide Valley and Pioneer Valley. The table on page 390 of this chapter provides the quantity and purpose of groundwater usage in these areas.

For more detailed information on Water Resources in Queensland see the chapter entitled *Land Settlement* in the latest edition of the Queensland Year Book.

South Australia

Administration

All major water resources and most public water supply schemes in South Australia are administered by the Engineering and Water Supply Department under the various statutes mentioned below.

- The Waterworks Act, 1932–1981, which empowers the Minister of Water Resources to impound or divert the water from any lake, watercourse or underground source for the purpose of establishing and maintaining public water supply schemes to serve proclaimed water districts throughout the State.
- The Water Conservation Act, 1936–1975, provides for the control of small reservoirs, bores, tanks, etc. established in remote areas as emergency water supplies or to assist local development.
- The River Murray Waters Act, 1935–1971, which ratifies the River Murray Waters Agreement, and under which the Engineering and Water Supply Department operates and maintains Lake Victoria storage, nine weirs and locks downstream of Wentworth, N.S.W., and barrages at the river mouth.
- The Water Resources Act, 1976–1981, which came into force from 1 July, 1976 and superseded the Control of Waters Act, 1919 and the Underground Waters Preservation Act, 1969, represents the culmination of the development of the Government's water resources policy involving the management of all aspects of water—surface and underground, quality and quantity. The Act provides for the control of diversions of surface waters from Proclaimed Watercourses and for the withdrawal of underground waters from Proclaimed Regions. Currently, the River Murray, Little Para River and Bolivar Effluent Channel are Proclaimed Watercourses, the Proclaimed Regions being the Northern Adelaide Plains, Padthaway and Angas-Bremer Irrigations. The legislation provides for control over the construction or modification of most categories of wells over the whole State and for the abatement of pollution of all waters. It establishes a South Australian Water Resources Council and Regional Advisory Committees as vehicles for public participation in the water resources management process. Currently, Regional Committees operate in respect of the River Murray; the Northern Adelaide Plains, Little Para River and Bolivare Effluent Channel; Padthaway; the North Para River; the Arid Areas and the Angas-Bremer Irrigation Area. In addition, the Act provides for a Water Resources Appeal Tribunal to give individuals the opportunity to appeal against decisions of the Minister pursuant to the Act.

Summary of schemes

Australian irrigation originated in the upper Murray in South Australia and the Mildura area of Victoria. South Australian irrigation commenced with an agreement involving the Chaffey brothers in 1887 whereby an area was made available for the establishment of certain irrigation works at Renmark. From this start, government, co-operative and private irrigation areas totalling more than 42,000 hectares have been developed in the South Australian section of the Murray Valley. The authority controlling River Murray irrigation is the Engineering and Water Supply Department which operates under policies determined by the Minister of Water Resources on advice of the S.A. Water Resources Council. The principal high land crops comprise citrus and stone fruits, and vines. The reclaimed swamps along the lower section of the Murray are used almost exclusively for pasture and fodder crops. Vegetable crops of various kinds are important in both types of irrigated lands.

Except for quantities held in various lock pools and natural lakes, no water from the Murray is stored within South Australia for irrigation purposes. Usage of the River is therefore planned on the basis of the minimum monthly flows to which South Australia is entitled under the River Murray Waters Agreement. This factor, plus the need to reserve water for city, town and rural water supply systems, has resulted in the expansion of irrigation from the River being rigidly controlled by the Government. In addition to irrigation from the River Murray there are considerable areas irrigated from underground sources by individual landholders in South Australia. The most important of these areas are the North Adelaide Plains (market gardens) and the Padthaway district of the south-eastern region (pastures, fodder, seed crops and vines).

CROP AND PASTURES IRRIGATED, BY METHOD OF IRRIGATION, SOUTH AUSTRALIA 1980–81
(Hectares)

Crops and Pastures	Method				Total
	Sprays	Furrows and/or Flood	Trickle	Other and multiple methods	
Pure Lucerne	9,160	2,970	n.a.	—	12,130
Other Lucerne-based pastures	2,499	521	n.a.	122	3,142
Other pastures (sown or native)	8,631	12,401	n.a.	281	21,313
Cereals for all purposes	1,379	924	n.a.	2	2,305
Vegetables for human consumption	5,167	303	26	180	5,676
Fruit	9,409	1,564	936	718	12,627
Grapevines	6,782	8,783	3,501	1,187	20,253
All other crops	1,329	601	17	81	2,028
Total	**44,356**	**28,067**	**4,480**	**2,571**	**79,474**

SOURCES OF IRRIGATION WATER, SOUTH AUSTRALIA 1980–81

Source of supply	Area irrigated	Percentage of total area irrigated
	(hectares)	%
Surface water		
from State irrigation schemes	19,121	24
from other schemes (including private group schemes)—		
from rivers, creeks, lakes, etc. (*a*)	18,454	23
from farm dams	3,331	4
Total surface water	*40,906*	*51*
Underground water supply (e.g., bore, spear, well) (*b*)	38,088	48
Town or country reticulated water supply	480	1
Total all water sources	**79,474**	**100**

(*a*) Includes regulated and unregulated streams. (*b*) Naturally or artificially replenished.

Adelaide Metropolitan Water Supply

In 1981–82, River Murray pipelines supplied 80 per cent of the total intake to the Metropolitan Adelaide Water Supply System. A maximum of 83 per cent was reached in 1977–78. The principal sources of supply for the ten storages in the Mt Lofty Ranges are the Rivers Onkaparinga, Torrens, South Para, Myponga and Little Para. For details on Adelaide Metropolitan Water Supply, see "Metropolitan Adelaide Water Resources Study", Engineering and Water Supply Department, June 1978.

Country reticulation supplies

A number of reservoirs in the Barossa Ranges and other local sources are augmented by the Morgan-Whyalla, Swan Reach-Stockwell and Tailem Bend-Keith pipelines which provide River Murray water to extensive country areas. A network of branch mains provides the means of conveying water to numerous towns and large areas of farmlands.

Surface and underground resources have been developed to supply most country centres not covered by the larger schemes. Victor Harbor and adjoining south coast resort centres are supplied from reservoirs and the River Murray. A reservoir on Kangaroo Island supplies Kingscote and adjacent farmlands. Underground resources of the lower south-east supply all towns in the region, the city of Mount Gambier and nearby farmlands being reticulated from the well-known Blue Lake. At the far northern opal mining town of Coober Pedy a reverse osmosis desalination plant provides a potable supply from brackish groundwater. Other centres in the far north obtain supplies from the Great Artesian Basin. For details on underground water resources in South Australia see "Underground Water Resources of South Australia", Bulletin No. 48, Department of Mines and Energy, Geological Survey of South Australia, 1978.

South-eastern drainage

A section of the South-East Coast Drainage Division extends into South Australia but has no co-ordinated drainage pattern to form a significant surface water resource. However, high rainfall in the area has led to the natural development of underground resources. Surplus water is not easily disposed of in the

valleys and low range terrain, so drainage systems have been undertaken by the Government in co-operation with landholders. For further details see "Environmental Impact Study on the effects of Drainage in the South East of South Australia", Southeastern Drainage Board, June 1980.

Murray River Irrigation Areas

Where irrigation water in excess of plant requirements has been applied, perched water tables develop. Rising to the level of tree roots, these cause the death of orchards from salination and water-logging. Most orchards and vineyards are now drained by plastic and tile drainage systems, thus restoring their health and productivity. At present, disposal of drainage water is achieved by pumping to basins on river flats where it evaporates or is discharged into the river when it is in flood. It may also be discharged into underlying sand and limestone aquifers. The usefulness of these aquifers is declining as they are becoming fully charged with water.

As a result of investigations made into alternative disposal schemes, a $25 million package of six salinity control measures was embarked upon in 1979. The measures combine engineering works, improved irrigation practices, and river regulation to reduce salinity to acceptable levels. The centrepiece of the programme is the Noora Drainage Disposal Scheme, progressive commissioning of which commenced in September 1982, with pumping from the Berri Basin.

When completed, the Scheme will allow drainage water presently held in river flat basins to be pumped to a large evaporation basin located well out of the river valley, approximately 20 km east of Loxton.

For more detailed information on Water Resources in South Australia see the chapter entitled *Physical Development* in the latest edition of the South Australian Year Book.

Western Australia

Administration

The Minister for Works and Water Resources administers the departmental irrigation schemes under the *Rights in Water and Irrigation Act, 1914–1978*. He is advised by an Irrigation Commission representing the local irrigationists and government, technical and financial branches. He also administers, under the *Country Areas Water Supply Act, 1947–1979*, the water supplies to certain country towns and reticulated farmland. As Minister for Works he controls minor non-revenue producing supplies to stock routes and a few mines and agricultural areas with their associated communities. A small number of town supplies are administered by local boards under the *Water Boards Act, 1904–1979*, which provides a large degree of autonomy with ultimate Ministerial control.

Irrigation

Irrigation schemes have been established by the Government on the coastal plain south of Perth in the Waroona, Harvey and Collie River and Preston Valley Irrigation Districts between Waroona and Donnybrook, the water being channelled from dams in the adjacent Darling Range. The success of dairying and stock raising and, to a lesser extent, vegetable growing, which have replaced citrus growing, has led to a gradual but substantial extension of irrigation areas in the south-west.

Although not yet comparable in size with the south-west irrigation districts, the irrigation areas at Carnarvon and on the Ord and Fitzroy Rivers in the Timor Sea Drainage Division in the north of the State are of increasing significance.

Since the mid 1930s, a centre of tropical agriculture has been developed at Carnarvon, near the mouth of the Gascoyne River. Initially, the principal source of irrigation water for the 160 plantations was private pumping from the sands of the Gascoyne River. Overpumping by the growers however, resulted in salt intrusion into the fresh water aquifer. Government controls were introduced and a major groundwater supply scheme upstream of the irrigation area has since been commissioned and provides approximately two-thirds of the irrigation water. The area specialises in growing bananas together with out of season vegetables for the Perth market. A tropical research station is maintained at Carnarvon by the Department of Agriculture.

The Ord River Irrigation Project in the Kimberley Division provides for the eventual development of an irrigation area of some 70,000 hectares of land, one third of which is in the Northern Territory. The first stage, in which water was supplied from the Kununurra Diversion Dam (capacity 98.7 mil. cubic metres) to 30 farms averaging 270 hectares plus a 970 hectare pilot farm was completed in 1965. Cotton was the principal crop, with grain sorghum and fodders for cattle fattening also important. Completion in 1971 of the Ord River Dam, which stores 5,720 mil. cubic metres in Lake Argyle, has allowed expansion of the area to be irrigated into the second stage. Five farms averaging 388 hectares were allocated in 1973. Since then, cotton has been phased out due to high off-farm costs and increasing costs of insect control specific to the cotton industry. Maize, peanuts and rice are the main crops being

grown at present with smaller areas of grain sorghum, soya beans, mung beans, pasture, cucurbits and bananas. A pilot sugar farm has produced high yields and has resulted in proposals for a sugar industry to be established. The proposals are being considered by the State Government.

The Camballin Irrigation District on the Fitzroy River flood plain in the West Kimberleys is dependent on diverted river flows and a small volume of storage behind the diversion structures on the Fitzroy River and Uralla Creek. Grain and fodder sorghums are the main crops. Although a large area was developed for irrigation, the expansion of activity that was expected by the Australian Land and Cattle Company was cut short in February 1982 when this company was placed in the hands of a receiver-manager and in May 1982 the receiver placed the project under 'care and maintenance'.

CROPS AND PASTURES IRRIGATED, BY METHOD OF IRRIGATION, WESTERN AUSTRALIA 1980–81

(Hectares)

	Method				
Crops and Pastures	*Sprays*	*Furrows and/or Flood*	*Trickle*	*Other and multiple methods*	*Total*
Pure Lucerne	755	63	n.a.	—	818
Other pastures (sown or native)	1,292	10,738	n.a.	339	12,369
Cereals for all purposes	147	589	n.a.	216	952
Vegetables for human consumption	2,219	321	39	299	2,878
Fruit	1,900	292	1,540	312	4,044
Grapevines	248	49	79	228	604
All other crops	468	2,436	58	74	3,036
Total	**7,029**	**14,488**	**1,716**	**1,468**	**24,701**

SOURCES OF IRRIGATION WATER, WESTERN AUSTRALIA 1980–81

Source of supply	*Area irrigated*	*Percentage of total area irrigated*
	(hectares)	%
Surface water		
from State irrigation schemes	13,547	55
from other schemes (including private group schemes)—		
from rivers, creeks, lakes, etc. (*a*)	2,132	7
from farm dams	4,672	19
Total surface water	*20,351*	*82*
Underground water supply (e.g., bore, spear, well) (*b*)	4,104	17
Town or country reticulated water supply	246	1
Total all water sources	**24,701**	**100**

(*a*) Includes regulated and unregulated streams. (*b*) Naturally or artificially replenished.

Country water supplies controlled by Department of Public Works

Since 1947 enlargement and extensions of the Goldfields and Agricultural Water Supply and the development of the Great Southern Towns Water Supply have been carried out, mainly in accordance with a project known as the Modified Comprehensive Scheme. Under this scheme water has been supplied to towns and farms in the cereal and sheep districts of the State. Two years after the completion of the 1.7 million hectare scheme in 1961, an extension of 1.5 million hectares was agreed to with Federal-State funding.

Goldfields and Agricultural Water Supply

Water for the Eastern Goldfields is supplied by pipeline from Mundaring Reservoir in the Darling Range. The scheme now serves over 92 towns and 2.7 million hectares of farmland.

Great Southern Towns Water Supply

This scheme provides water to towns and localities from Wellington Dam to Narrogin and along the Great Southern Railway from Brookton to Tambellup, supplying 31 towns and 0.6 million hectares of farmland.

Local and Regional Water Supplies

As well as the two major water supply schemes, above, water is also supplied by the Government from 12 Regional Water Supply schemes to 43 towns and from 99 local water supply schemes to 101 towns. The water comes from a variety of sources including underground, artificial catchments and stream flow.

Underground water

Considerable use is made of groundwater by individual farmers, pastoralists, market gardeners and others, although the water quality varies from place to place and much of it is too saline for irrigation or even stock purposes. Artesian wells throughout the State and non-artesian wells within 'declared' areas must be licensed under the *Rights in Water and Irrigation Act, 1914–1978*. Industries also use groundwater in substantial quantities, especially in the processing of titanium, iron and alumina, and this demand has intensified the search for groundwater.

For more detailed information on Water Resources in Western Australia see the chapter entitled *Land Tenure and Settlement, Water Supply and Sewerage* in the latest edition of the Western Australian Year Book.

Tasmania

Main purposes of water conservation and utilisation

Because of the generally more adequate rainfall in Tasmania, scarcity of water is not such a problem as it is in most mainland areas, though not all streams are permanently flowing. The only large-scale conservation by reservoirs is for hydro-electric power generation, but there are some moderately-sized dams built by mining and industrial interests and by municipal authorities for town water supplies. 'Run of the river' schemes are quite adequate for assured supply in many municipalities. The main supply for Hobart and adjacent municipalities originates from a 'run of the river' scheme based on the Derwent River. The river is controlled in its upper reaches by eight dams, built for hydro-electric power generation, and these tend to stabilise river flow.

Until a few years ago irrigated areas were negligible except for long established hop fields, but there is a rapidly expanding use of spray irrigation on orchards, pastures, potatoes, beans and peas. Until recent years there has been almost complete dependence on natural stream flows, but the need for some regulating storages has become apparent. Increasingly, farmers are constructing storages of their own and the extension of this practice is foreseen as the logical solution in most areas, as valleys are narrow and steep sided. Single large reservoirs cannot economically serve large areas of suitable land, as nearly every valley is separated from others by pronounced hills, prohibiting the construction of cross-country channels.

Underground water suitable for stock, minor irrigation works and domestic use is exploited in the consolidated rocks of southern, midlands and north-western Tasmania. In the south and midlands, nearly all groundwater is obtained from Permian and Triassic rocks. In the north-west, water is recovered from a variety of rocks ranging from Precambrian dolomites, quartzites and schists to Tertiary basalts and Quaternary sands. The highest yields are obtained from the dolomites and the basalts. In the central north and north-east, unconsolidated Tertiary clays and gravels yield water of variable quality. In some coastal areas, notably King and Flinders Islands, water is obtained from aeolian sands.

The Mines Department is charged with the investigation of underground water resources. There is a great reserve of untapped permanent streams in the western half of the State, which is largely unsettled. The State's largest rivers discharge in the west, but diversion to the eastern half of the watersheds is not regarded as practicable. The Hydro-Electric Commission, however, has planned for the future development of four storage dams in the West Coast region on the Pieman, Murchison and Mackintosh Rivers.

Administration

In Tasmania, water supply was once exclusively the responsibility of local government authorities, but three statutory authorities, the Metropolitan Water Board, the Rivers and Water Supply Commission and the North West Regional Water Authority, now operate bulk supply schemes, piping water for distribution by the local government authorities in the Hobart, Launceston and N.W. Coast regions, and directly to certain industrial consumers. The Board is responsible for bulk supplies to the Hobart, Clarence, Glenorchy to Kingborough, Brighton, Green Ponds, New Norfolk, Richmond and Sorrell local government areas, while the Commission exercises a general control over the utilisation of the State's water resources and has specific functions in relation to local government authority water, sewerage and drainage schemes. The Authority controls the supply of water to the municipalities of Circular Head, Wynyard, Penguin, Ulverstone, Devonport, Latrobe and Kentish.

Rivers and Water Supply Commission. The Commission is empowered by the *Water Act* 1957 to take water at streams and lakes, or to issue others with licences to do so; licensing covers supply to specific industries and municipalities as well as for irrigation. The Commission is concerned with drainage trusts' operations, river improvements (including repairs after flood damage), stream gauging, its own regional water schemes, and with water supply, sewerage and drainage of towns. It operates in a similar manner to the Metropolitan Water Board in controlling the water schemes serving the East Tamar region (North Esk Regional Water Supply), the West Tamar area (West Tamar Water Supply) and the Prosser River Scheme, which was originally constructed to supply water to a sodium alginate industry at Louisville near Orford and to supplement the water supply of the township of Orford. The sodium alginate industry ceased production in December 1973. The North Esk Regional Water Supply was constructed to meet industrial requirements of the alumina refinery and other industries at Bell Bay, and to provide bulk supplies to surrounding municipalities on the eastern bank of the River Tamar and has since been augmented by the construction of a dam on the Curries River to supply the northern end of the Tamar Valley. The West Tamar Water Supply was constructed primarily to meet domestic requirements of urban areas in the Beaconsfield municipality. The local government authorities retain primary responsibility for reticulation and sale to consumers, except to certain industrial users.

In municipalities not serviced by the Metropolitan Water Board, the Rivers and Water Supply Commission or the North West Regional Water Supply Authority, the supply of water is a function of the local municipal council. Where the construction of water and sewerage schemes is beyond the financial capacity of a local government authority, or if it requires assistance to pay for water supplied from regional schemes, the Commission may make recommendations to the Minister for payment of a subsidy.

Irrigation

The Cressy-Longford Irrigation Scheme officially opened in 1974 and was the first major State irrigation project to be established in Tasmania. The source of supply is the Tailrace of the Poatina Hydro-Electric Power Station from which up to 160 thousand cubic metres per day may be available to farmers inside the Irrigation District and along the Liffey River downstream from Pitts Lane.

There are some 10,000 hectares fit for irrigation within the Irrigation District, half of which may be watered by gravity. The Scheme serves some seventy-two farms within the Irrigation District and another thirty may be supplied on the Liffey River and on the fringes of the Irrigation District.

Besides the Cressy-Longford Irrigation Scheme which is operated by the Rivers and Water Supply Commission, the following local bodies supply water for irrigation or inter-alia exercise control over its availability: the Lawrenny Water Trust on the Ouse River, the Clyde Water Trust on the Clyde River, the Macquarie Water Trust on the Macquarie River at Ross and the Campbell Town Council on the Elizabeth River.

The major portion of the 32,748 hectares irrigated in the State in 1980-81 were watered by private schemes either by pumping directly from unregulated streams or from on farm storages. Pasture still predominates as the main crop watered but potatoes and vegetables amount to 34 per cent of the total area irrigated.

CROPS AND PASTURES IRRIGATED, BY METHOD OF IRRIGATION, TASMANIA 1980-81

(Hectares)

	Method				
Crops and Pastures	*Sprays*	*Furrows and/or Flood*	*Trickle*	*Other and multiple methods*	*Total*
Pure Lucerne	773	29	n.a.	33	835
Other pastures (sown or native)	7,080	6,741	n.a.	320	14,141
Cereals for all purposes	1,231	43	n.a.	29	1,303
Vegetables for human consumption	10,351	57	n.p.	893	(*a*) 11,301
Fruit	1,620	102	553	200	2,475
All other crops	2,346	235	n.p.	98	(*a*) 2,679
Total	**23,401**	**7.207**	**567**	**1,573**	**32,748**

(*a*) Incomplete.

SOURCES OF IRRIGATION WATER, TASMANIA 1980-81

Source of supply	*Area irrigated*	*Percentage of total area irrigated*
	(hectares)	%
Surface water		
from State irrigation schemes	1,798	6
from other schemes (including private group schemes)—		
from rivers, creeks, lakes, etc. (*a*)	14,213	43
from farm dams	15,623	48
Total surface water	*31,634*	*97*
Underground water supply (e.g., bore, spear, well) (*b*)	755	2
Town or country reticulated water supply	359	1
Total all water sources	**32,748**	**100**

(*a*) Includes regulated and unregulated streams. (*b*) Naturally or artificially replenished.

For more detailed information on Water Resources in Tasmania see the chapter entitled *Local Government* in the latest edition of the Tasmanian Year Book.

Northern Territory

Information on climatic conditions can be found in the chapter Climate and Physical Geography of Australia. A brief outline of contour and physical characteristics is in Chapter 27, The Territories of Australia.

Administration

Under the Northern Territory *Control of Waters Ordinance* 1938, control of natural waters is 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). The diversion of water is prohibited except under prescribed conditions. The Act requires that drilling for groundwater be carried out only by drillers who are registered under the Act. Registered drillers are required to provide the Government with information on bores drilled, including the location, depth and size of bore, strata encountered and water produced. In particular areas, described as Water Control Districts, where stricter control is necessary, the construction or use of a well or water bore without a permit can be prohibited.

Under the *Water Supplies Development Act* 1960, any landholder engaged in pastoral or agricultural production may seek information or advice from the Commissioner of Water Development who is appointed under the Act. He may also apply for an advance towards the cost of work proposed to be carried out. The Act also provides for a refund to the landholder of the cost of drilling an unsuccessful bore where the landholder has applied to the Commissioner for advice on its construction and has carried out all drilling operations in accordance with advice given.

The Water Division of the Department of Transport and Works carries out systematic stream gauging, the collection of data relating to the quantity and quality of surface and groundwater, the planning of water use for industrial, irrigation and town water supplies, and flood prevention and control. It also provides a general advisory service to the public on water resources and water conservation by providing information on the geology of the Territory, the prospects of obtaining groundwater, the possible location of bore sites, the method of drilling and equipping bores, stream flows, surveys of dam sites, the design of water supply schemes and reticulation lay-outs, and the chemical and bacteriological quality of water supplies. It is involved in water pollution studies and control,and carries out environmental assessments of water and related developments. The Division administers both of the acts described.

Underground water

For information on underground water resources in the Northern Territory *see* Year Book No. 55 and earlier issues, and the Australian Water Resources Council's publication, *Groundwater Resources of Australia,* 1972 and *Review of Australia's Water Resources,* 1975.

Of approximately 12,500 bores and wells registered in the Territory up to 30 June 1979, 51 per cent were for pastoral use, 13 per cent were investigation bores, 13 per cent served town and domestic supplies, 5 per cent were for crop use, 4 per cent were used on mining fields, and the remainder for various other uses.

Community water supplies

The largest water conservation projects in the Territory are the Darwin River Dam (259.0 million cubic metres) and the Manton Dam (15.7 million cubic metres) which both serve Darwin with a reticulated water supply. Groundwater from McMinns Lagoon area can be used to augment supply.

Most other towns and communities, including Alice Springs, Tennant Creek, Katherine, Jabiru and Nhulunbuy, are supplied from groundwater.

Investigations are continuing into groundwater supplies for aboriginal communities and irrigation supplies in the Alice Springs District and the Daly River basin.

Surface water measurement

The hydrological investigations required in the Northern Territory as part of the National Water Resources Assessment Program are being carried out by the Water Division. The program for the Northern Territory includes establishment of base streamgauging stations and pluviographs (automatic rainfall recorders). In particular areas of development where water supply or irrigation proposals require special or extra surface water data, supplementary gauging stations are built to obtain this information. Intensive studies are being undertaken in the Alligator Rivers Region and other mining areas for the collection of both quantitative and qualitative data for environmental and management purposes. The streamgauging network of the Division comprises gauging stations (base gauging and supplementary) and pluviographs. Several other organisations also operate gauging stations and pluviographs in the Northern Territory.

Irrigation for agricultural purposes in the Territory is not extensive, being confined to isolated locations near Darwin, Adelaide River, Coomalie Creek, Daly River, Katherine, Douglas River, Ti Tree and Alice Springs for the purpose of growing fruit, vegetables, fodder crops, pastures and some dairying. Some of this irrigation is carried out using bore water.

Both the Daly and Adelaide Rivers offer considerable potential for the development of either irrigation or hydroelectric schemes if these rivers were regulated. Investigations are being conducted into possible dam sites, agricultural surveys having already been conducted in these regions. There is increasing demand for water resources assessment studies and assistance for relatively small irrigation projects, and for investigation and design of surface water storages for recreational uses, especially in the more arid regions.

Australian Capital Territory

The climate of the Australian Capital Territory is such that annual evaporation exceeds the annual rainfall of about 600 mm. Primary producers have therefore found it necessary to practise water conservation, and to irrigate from groundwater supplies during dry periods.

Surface water

Surface water storages supplying Canberra (population about 228,000) and the city of Queanbeyan (population about 21,000) are located to the south-west and south-east. The storages to the south-west are in the heavily timbered, mountainous Cotter River catchment within the A.C.T., the storages being Corin Dam (75.5 million cubic metres), Bendora Dam (10.7 million cubic metres) and Cotter Dam (4.7 million cubic metres). These storages, can serve a population of 225,000. The storage to the south-east is in New South Wales in the Queanbeyan River catchment on the western slopes of the Great Dividing Range, the storage being Googong Dam (125 million cubic metres). This storage was only recently commissioned and can serve 70,000 people with the current trunk mains and distribution system. The total volume of water in storage at 30 June 1980 was 157 million cubic metres.

The existing storages on the Cotter and Queanbeyan River have an ultimate combined capacity to serve 450,000 persons. The remaining water resource within the A.C.T. is the Gudgenby River which is at present not utilised but has the potential to serve approximately 200,000 persons.

The A.C.T. water supply system is operated by the Department of Transport and Construction. This Department operates a network of stream gauging stations in the A.C.T. to monitor surface water resources. A number of the gauging stations are provided with telemeters which enable the Department to provide a flood warning system in association with the Bureau of Meteorology.

Groundwater

Groundwater in the A.C.T. and environs occurs mainly in fractures in crystalline rock such as granite and volcanic rocks; in folded and fractured slate; and rarely, in solution cavities in limestone. Alluvial aquifers of significance are restricted to the Lake George basin and small areas along mature sections of the Molonglo and Murrumbidgee Rivers. Groundwater has been used in the past by most primary producers to augment surface storage. Groundwater production bores in the A.C.T. have

yields ranging between about 0.4 and 20 cubic metres per hour; 3 cubic metres per hour is about the average yield. However, many farm bores have fallen into disuse as a result of the Government's resumption of freehold land within the A.C.T., and because of the rapid expansion of urban growth. The Bureau of Mineral Resources has provided a bore-siting, groundwater-quality and yield-prediction service in and around the A.C.T. since the early 1950's and until 1978 maintained a network of 48 observation bores which were monitored regularly for up to 25 years. Periodic monitoring of the bores recommenced in 1980 as a consequence of greatly increased demand for the Bureau's rural bore siting services during the current drought. Data are now being collected on groundwater occurrences within the A.C.T. and environs for preparation by the Bureau of a 1:100,000 scale hydrogeologic map.

Many bores have been drilled in the Canberra area for determination of ground conditions for specific projects such as dam sites, sewer tunnels, deep foundations for large buildings; disposal of household and industrial wastes, including radioisotopes; monitoring hydrocarbons, pollution of groundwater or for feasibility studies for urban development. These bores are generally monitored for short periods only. Long-term monitoring of water infiltrating from refuse-disposal areas commenced in 1977.

Control of irrigation and farm water supplies is exercised by the Conservation and Agriculture Branch of the Department of the Capital Territory. The Bureau of Mineral Resources of the Department of National Development and Energy provides technical advice to landholders and drilling contractors on groundwater and, occasionally, on runoff.