CHAPTER 15

WATER RESOURCES

This chapter is divided into two major parts:—existing 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 agriculture (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 quantity.

Topography. The major topographical feature affecting the rainfall and drainage patterns in Australia is the absence of high mountain barriers. Australia's topographical 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 but 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 alpine to 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. Development, however, has not been without costs. Significant environmental degradation and deterioration in water quality are becoming evident.

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 recently assessed at 440 x 10^9 cubic metres, of which 118 x 10^9 cubic metres is now estimated to be exploitable for use on a sustained yield basis. 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 84 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 13 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 instream purposes which does not affect the quantity of water available. However, the great variability of river discharge, high evaporation, lack of sites for storage on many catchments, and economic considerations limit potential development. There is, however, considerable scope for greater efficiency in water use.

Groundwater supplies

About 80% of Australia is significantly dependent on groundwater supplies. Australia's estimated sustainable groundwater yield is 72 x 10^9 cubic metres, and annual groundwater usage is estimated at about 2.5 x 10^9 cubic metres.

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. As a general rule, groundwater from shallow unconsolidated sediments is of good quality but there are instances where groundwater has been polluted, particularly around major urban centres, by sewerage effluent, drainage from refuse tips and from specific industrial pollutants. Supplies from sedimentary basins and fractured rocks are more variable in both quality and quantity, especially in the more arid regions of the continent. High nitrate concentrations tend to be a common occurrence in groundwaters in northern and central Australia.

Drainage divisions and the use of surface and groundwaters

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.

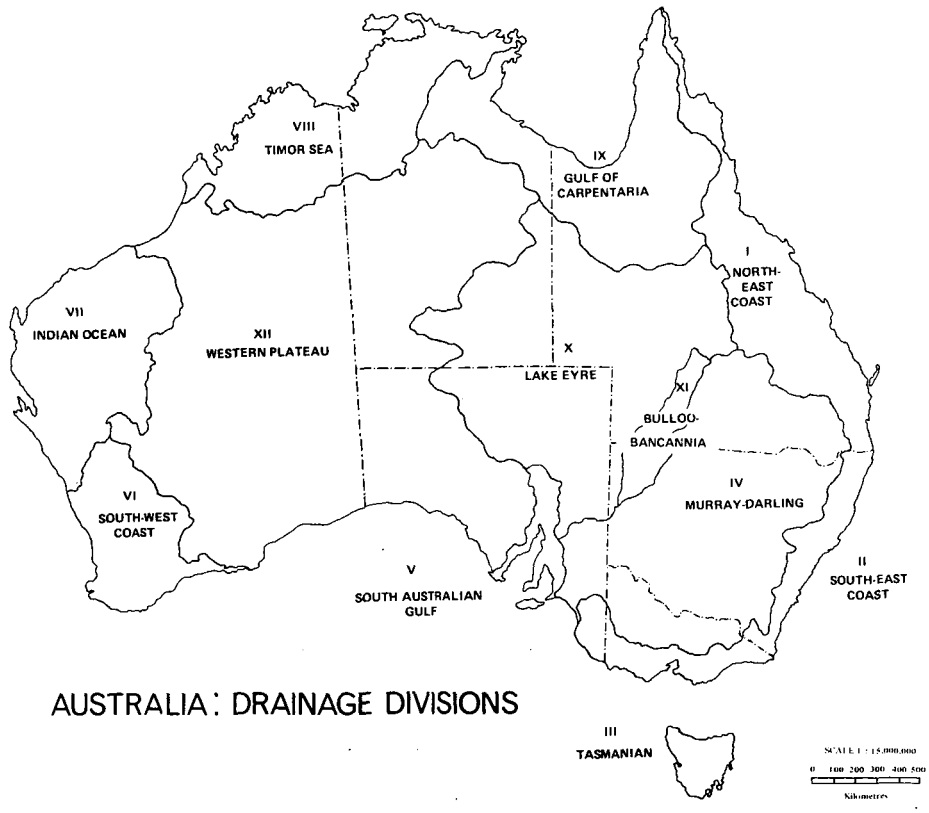

PLATE 41

In a recent report on Australia's water resources—*Water 2000*, Department of Resources and Energy, Canberra 1983, the 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, has been re-assessed. 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.

SURFACE WATER: ESTIMATES OF RUNOFF, TOTAL POSSIBLE EXPLOITABLE YIELD AND CURRENT USE BY DRAINAGE DIVISIONS

Sources: Snowy Mountains Engineering Corporation 1983; Australian Water Resources Council 1981

Drainage division		*Surface water (thousand million M^3 per annum)*			*Use as percentage of exploitable yield(%)*
		Runoff	*Total possible exploitable yield(a)*	*Use(b)*	
I	North-East Coast	91	26	0.9	3
II	South-East Coast	45	15	2	13
III	Tasmania	53	35	0.3	1
IV	Murray-Darling	23	13	11	85
V	South Australian Gulf	1	0.3	0.1	33
VI	South-West Coast	7	2	0.4	20
VII	Indian Ocean	4	0.2	ns	—
VIII	Timor Sea	81	16	0.1	1
IX	Gulf of Carpentaria	131	10	ns	—
X	Lake Eyre	3	0.1	ns	—
XI	Bulloo-Bancannia	,1	ns	ns	—
XII	Western Plateau	ns	ns	ns	—
Australia	. . . . .	**440**	**117.6**	**14.8**	**13**

(*a*) Exploitable yield is estimated total divertible fresh and marginal water at the lowest practicable point of impoundment, taking account of technical factors but not economic, environmental or social constraints. (*b*) Urban, industrial and agricultural uses of water only. In-stream uses such as hydro-electric generation are not included.
ns = not significant.

Water quality

The quality of surface waters in Australia varies greatly and is controlled by climate, geology, stream flow rates, biological activity and land use. Most of the variability is related to water events such as storm flows, floods and drought. Water pollution is generally at a low level compared to other similarly developed countries. The great majority of Australians enjoy domestic, irrigation and recreational waters of good to excellent quality.

Very little is known of the water quality conditions which prevailed prior to European settlement and development in Australia. It is thus difficult to judge the full impact of urban, agricultural, industrial and mining developments, and the effects that water resource development measures, such as large dams, have had on the quality of the resource. Levels of toxic pollutants have undoubtedly increased, as have the salt and sediment loads of the rivers. While water quality would, at times, have been poor prior to settlement, quality levels are believed to have generally declined. On the other hand, regulation of major rivers has reduced some of the water quality impacts of floods and droughts.

A better appreciation of water quality in recent times has led to much improved management. Measurable improvements in water quality over the last decade have resulted from pollution controls in industry and mining, and more effective sewage treatment. Means of control of pollution from widespread agricultural activity such as problems of salinity and turbidity, are under development.

The major water quality issues and problems faced in Australia are salinity, turbidity, excessive plant and algal growths (eutrophication), and water treatment for small community water supplies. There is also a lack of data, information and research on all aspects of water quality and the protection of aquatic species and habitats. Many of the severe pollution problems found in other countries have been avoided in Australia, because of the general absence of highly polluting industries and the location of major cities on or near the coastline enabling ocean disposal of wastes.

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 but 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. The possible yield and use of groundwaters in the twelve drainage divisions is shown below.

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.

GROUNDWATER ESTIMATES OF TOTAL POSSIBLE YIELD AND CURRENT USE BY DRAINAGE DIVISION

Sources: Bureau of Mineral Resources 1983; Australian Water Resources Council 1981

Drainage division		*Groundwater (thousand million M^3 per annum)*		
		Total possible yield (a)	*Use (b)*	*Use as percentage of possible yield (%)*
I	North-East Coast	3	0.7	23
II	South-East Coast	4	0.5	13
III	Tasmania	16	ns	—
IV	Murray-Darling	6	0.8	13
V	South Australian Gulf	0.03	0.08	267(c)
VI	South-West Coast	2	0.2	10
VII	Indian Ocean	0.3	0.05	17
VIII	Timor Sea	21	0.03	0.1
IX	Gulf of Carpentaria	14	0.02	0.1
X	Lake Eyre	2	0.02	1.0
XI	Bulloo-Bancannia	0.05	ns	—
XII	Western Plateau	2	0.03	2.0
Australia	. . . . .	70.38	2.43	3.5

(*a*) Potential yield is annual recharge plus depletion of the aquifer at a rate of 1% per annum. Fresh groundwater has less than 1000 parts per million total dissolved solids. (*b*) Urban, industrial and agricultural uses only of water of any quality. (*c*) Includes use of a significant proportion of marginal and brackish water. If groundwater in excess of 1000 parts per million total dissolved solids were included, the ratio would be 88%. ns = not significant

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 ($10^6 M^3$)*				*Ground waters ($10^6 M^3$)*				*Totals ($10^6 M^3$)*			
	Urban industrial	*Irrigation*	*Other rural*	*Total (a)*	*Urban industrial*	*Irrigation*	*Other rural*	*Total (a)*	*Urban industrial*	*Irrigation*	*Other rural*	*Total (a)*
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

(*a*) 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 10^6 cubic metres 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 titled *Australia—Dams and Storages*, published in 1975 by the Department of Minerals 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. 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	H/E, IR, R, U
Hume (1936, 1961)	Murray River, near Albury	3,038	51	H/E, IR, R, U
Warragamba (1960)	Warragamba River	2,057	137	H/E, U
Menindee Lakes (1960)	Darling River, near Menindee	1,794	18	IR, R, U
Burrendong (1967)	Macquarie River, near Wellington	1,677	76	F/C, IR, R, U
Blowering (1968)	Tumut River	1,628	112	H/E, IR, R
Copeton (1976)	Gwydir River	1,364	113	IR, R, U
Wyangala (1936, 1971)	Lachlan River	1,220	85	IR, R
Burrinjuck (1927, 1956)	Murrumbidgee River	1,026	79	IR, R
Talbingo (1971)	Tumut River	921	162	H/E, IR, R, U
Jindabyne (1967)	Snowy River	688	72	H/E, IR, R, U
Lake Victoria (1928)	Murray River, near S.A. border	680	–	IR, R, U
Keepit (1960)	Namoi River, near Gunnedah	423	55	F/C, IR, U
Windamere (1984)	Cudgegong River, near Mudgee	368	69	IR
Glenbawn (1958)	Hunter River, near Scone	360	78	F/C, IN, IR, R, U
Glennies Creek (1983)	Hunter Valley, near Singleton	284	67	IN, IR ,R, U
Tantangara (1960)	Murrumbidgee River	254	45	H/E, IR ,R, U
Avon (1927)	Avon River	214	72	U
Mangrove Creek (1983)	Mangrove Creek, near Gosford	176	79	U
Grahamstown (1969)	Grahamstown, near Newcastle	153	12	IN, U
Lake Brewster (1952)	Lachlan River, near Hillston	150	–	IR, R
Liddell (1968)	Gardiner Creek, near Muswellbrook	148	41	IN
Tallowa (1977)	Shoalhaven River, near Nowra	135	43	U
Googong (1978)	Queanbeyan River	125	59	U, F/C
	VICTORIA			
Dartmouth (1979)	Mitta Mitta River	4,000	180	F/C, H/E, IN, IR, R
Eildon (1927, 1955)	Upper Goulburn River	3,392	79	F/C, H/E, IN, IR, R
Thomson (1984)	Thomson River, near Moe	1,175	164	IR, U
Waranga (1910)	Near Rushworth (Swamp)	411	12	IR, U
Mokoan (1971)	Winton Swamp, near Benalla	365	10	IR
Rocklands (1953)	Glenelg River	336	28	R, U
Eppalock (1964)	Campaspe River	312	45	IR, U
Cardinia (1973)	Cardinia Creek, near Emerald	287	79	U
Upper Yarra (1957)	Yarra River	207	89	U
Blue Rock (1984)	Tanjil River, near Moe	200	75	IN, U
Glenmaggie (1927, 1958)	Macalister River	190	37	IR
Cairn Curran (1958)	Loddon River, near Newstead	149	44	IR
Yarrawonga (1939)	Murray River	117	22	IR
Toolondo (1952,1960)	Natural depression, near Horsham	107	–	IR, R
	QUEENSLAND			
Fairbairn (1972)	Nogoa River, near Emerald	1,440	49	IN, IR
Wivenhoe (1984)	Brisbane River, near Ipswich	1,150	59	F/C, H/E, U
Somerset (1959)	Stanley River, near Esk	893	50	U
Fred Haigh (1975)	Kolan River, near Gin Gin	586	52	IR
Ross River (1974)	Near Townsville	417	35	F/C, U
Tinaroo Falls (1958)	Barron River, near Atherton	407	47	H/E, IR
Glenlyon (1976)	Pike Creek, near Stanthorpe	254	62	IR
Awoonga High Down (1984)	Boyne River, near Gladstone	250	45	IN, U
Boondooma (1983)	Boyne River, near Proston	212	50	IN, IR
North Pine (1975)	North Pine, near Brisbane	205	44	U
Koombooloomba (1961)	Tully River, near Ravenshoe	201	52	H/E
Wuruma (1968)	Nogo River, near Eidsvold	194	46	IR
Eungella (1969)	Broken River, near Eungella	131	46	IN, U
Julius (1977)	Leichhardt River, near Mt Isa	127	35	IN, U
Leslie Dam Stage II (1985)	Sandy Creek, near Warwick	108	34	IR, U
Lake Moondarra (1957)	Leichhardt River, near Mt Isa	107	27	IN, U
Beardmore (1972)	Balonne River, near St George	101	15	IR, R

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*
WESTERN AUSTRALIA				
Lake Argyle (Ord) (1971)	Ord River, near Kununurra	5,720	99	F/C, H/E, IR
South Dandalup (1973)	Near Dwellingup	208	41	U
Wellington (1933, 1944, 1960)	Collie River	185	37	IR, R
Serpentine (1961)	Serpentine River	185	55	U
TASMANIA				
Lakes Gordon and Pedder (1974)—				
Gordon	South West	11,728	140	H/E
Scotts Peak	South West	2,963	43	H/E
Serpentine	South West	2,963	38	H/E
Edgar	South West	2,963	17	H/E
Miena (1967)	Great Lake	2,390	18	H/E
Lake St Clair (1938)	Central Plateau	2,000 (est.)	3	H/E
Mackintosh (1980)	Mackintosh River, near Queenstown	922	75	H/E
Tullibardine (1979)	Tullibardine River, near Queenstown	922	25	H/E
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
Bastyan (1983)	Pieman River, near Queenstown	124	75	H/E
Cethana (1971)	Forth River, near Devonport	108	110	H/E
NORTHERN TERRITORY				
Darwin River (1972)	Darwin River	259	31	U

(*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, F/C—Flood control and/or mitigation, IN—Industrial and/or mining, IR—Irrigation, R—Rural-stock and domestic, U—Urban supplies.

MAJOR DAMS AND RESERVOIRS UNDER CONSTRUCTION OR PROJECTED

Name	*Location*	*Gross capacity (million cubic metres)(a)*	*Height of wall (metres)(b)*	*Purpose*
UNDER CONSTRUCTION				
Burdekin Falls Dam	Burdekin River, near Townsville, Qld	1,860	68	IR
Huxley Dam	King River, near Queenstown, Tas.	1,060	100	H/E
Glenbawn Dam enlargement	Hunter River, near Scone, N.S.W.	870	100	F/C, IN, IR, R, U
Lower Pieman	Pieman River, near Queenstown, Tas.	641	122	H/E
Split Rock	Manilla River, Namoi Valley N.S.W.	370	66	Irrigation
Callide Dam (Stage II)	Callide Creek, near Biloela, Qld	127	35	IR, U
Bjelke Petersen	Barker Creek, near Murgon, Qld	125	33	IR
Harding Dam	Harding River, W.A.	114	42	Water supply
PROJECTED				
Spencer	Denison Creek, near Nebo, Qld	127	24	Mining, water supply

For footnotes and abbreviations *see* previous table.

Water management

Australia's water resources are managed by a multitude of 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 consumption, 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.

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.

Water 2000—A Perspective to the Year 2000

In 1982, the Commonwealth Government commissioned a study to provide a perspective on Australia's water resource needs and problems to the year 2000. The Steering Committee Report and a series of 13 consultants' reports were completed in 1983 and are available for purchase by the general public at Australian Government Publishing Service outlets.

The Water 2000 report indicated in general terms that Australia has sufficient surface and underground water to meet anticipated demands to the year 2000 at reasonable costs; however, regional or local shortages of water supply already occur and will continue.

In a general context, the report identified a number of major issues facing the water industry over the next two decades.

These were:

- protection and improvement of water quality
- more efficient use of currently available water supplies
- conservation of existing water supplies by more appropriate allocation and financial policies
- co-ordinated management and use of water and land resources
- adequate provision for instream uses
- improvements in data collection and analysis and information dissemination
- provision of adequate funding for water resources purposes including research, and
- continuing Commonwealth Government involvement.

Financial constraints, as well as environmental and social considerations were seen likely to lead to an increasing emphasis on greater efficiency in the use of existing supplies including the use of treated wastewater and marginal quality water for non-potable purposes. Substantial scope was seen to exist for improved efficiency in water use, particularly in irrigation.

Commonwealth water policy

In September 1984, the Commonwealth released its new water policy based on the recommendations of the Water 2000 report. Objectives of the new policy are:

- the availability of water, adequate in quantity for all beneficial uses
- the adoption of measures which improve the efficiency of water supply and use
- the development of a comprehensive approach to inter-related water and land management issues
- the encouragement of comprehensive long-term plans for the development and management of water resources, and
- the implementation of financial and economic policies which distribute the costs of water supplies equitably and provide incentives for the more economic use of resources at government and individual level.

As part of the new water policy, funds will continue to be provided to the States under a new program, the Federal Water Resources Assistance Program (FWRAP), to operate as from 1984-85. Funds will be available to the States and the Northern Territory for a range of purposes including:

- water resource development or management activities/projects for agricultural, urban or industrial purposes

- floodplain management
- collaborative information programs
- salinity reduction and land drainage
- State-wide and broad regional water plans, and
- public education.

Funds approved in 1983-84 under the Community Employment Program will continue to be available in 1984-85 for water supply improvement projects in country towns.

Research and continuing assessment of water resources

Australian Water Resources Council (AWRC)

The Australian Water Resources Council was established in 1963 by joint action of the Commonwealth and State Governments. The Council consists of the Commonwealth and State Ministers who have primary responsibility for water resources; it is chaired by the Commonwealth Minister for Resources and Energy.

The Council provides a forum for the exchange of views on water-related issues, and has been instrumental in promoting co-operation and collaboration on matters of mutual interest to its members. Its terms of reference include the promotion of programs to assess Australia's water resources, the encouragement of education and training in hydrology, the co-ordination and dissemination of information, the promotion of water research and development of liaison with overseas and international organisations in the field of water resources.

The Council is supported by a Standing Committee of permanent heads of relevant State and Commonwealth departments and authorities, and by six permanent technical committees and various fixed-term working groups and panels. Permanent technical committees have been established to tackle ongoing issues in groundwater, surface water, water quality management, catchment management, planning and management, and research and development, while working groups have examined such issues as research needs, education and training and the problem of aquatic weeds.

The AWRC's functions and advisory committee systems are under review to ensure that all important current and emerging issues are fully addressed in this important forum, with a view to developing compatible approaches to matters of mutual and national concern.

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

Water resources assessment

In 1964 in response to a perceived lack of water resouces data in all States the Commonwealth Government instituted through the AWRC the National Water Resources Assessment Program. The original aim was to expand the stream gauging network in Australia and increase the level of groundwater knowledge. In 1976 the collection of water quality data was added to the program. The program has been successful in filling many of the data gaps which existed prior to 1964 and in providing data and information for water resources planning, construction projects and in the development of the understanding of the nature and function of Australia's water resources. Discussions are currently underway with the States on the implementation of a new program of water resources data collection and information dissemination.

Water resources research

The Department of Resources and Energy is primarily responsible for the Commonwealth interests in water resource matters, including research policy and co-ordination at the Commonwealth level. The Department does not perform research, but has provided funds for and has administered a water research program on behalf of the AWRC. $500,000 has been made available in 1984-85 to support projects of 2-3 years duration in fields such as aquatic biology, effluent treatment, drinking water quality, evapo-transpiration, salinity and soil-water interaction. The AWRC is the major mechanism for the development of Commonwealth/State collaborative water programs.

Water research is undertaken at the Commonwealth level by the Commonwealth Scientific and Industrial Research Organization (CSIRO), the Bureau of Meteorology, the Australian Atomic Energy Commission (AAEC) and the Bureau of Mineral Resources, Geology and Geophysics (BMR). The water research programs of these major national agencies are coordinated through a Water Research Liaison Committee which advises the Ministers of Resources and Energy and of Science and Technology on water research in Commonwealth Government agencies.

At the State level, water agencies have extensive laboratory facilities for water quality testing. However, most water related research is undertaken in research centres associated with agriculture, fisheries, forestry and environmental authorities. At the regional level, some of the larger authorities providing water supply and sewerage services undertake applied research on a very limited scale.

A significant proportion of Australian water research is undertaken by researchers in tertiary education institutions with the aid of either internal funding or grants from outside bodies, such as the AWRC or the Australian Research Grants Committee. Water research is carried out within a range of disciplines, including the biological and social sciences and engineering.

A review of water research was undertaken by an Interim Council established in November 1983 to examine the need for and possible role of an Institute of Freshwater Studies. The Interim Council recommended the establishment of an independent advisory council, supported by a National Office of Water Research within the Department of Resources and Energy, to advise the Government of national water research priorities and an associated program of research. The Interim Council also recommended a substantial increase in funds for water research. The Commonwealth Government has yet to respond to the report.

CSIRO is the major national body undertaking water research. The principal water research groups in CSIRO are:

- *Division of Groundwater Research.* The Division's work seeks to understand the consequences of heterogeneity in soil and aquifer properties on a variety of scales and how they impinge on the movement of water and solutes into soils and aquifers. The Division develops and applies physical and geochemical techniques and instruments to investigate these questions.
- *Centre for Irrigation Research.* Programs at the Centre deal with the management of aquatic weeds and related aspects of water quality with special emphasis on turbidity in the Murrumbidgee system, the low-cost treatment of wastewaters utilising aquatic weeds, and the development of on-farm measures to ensure the most effective and efficient use of irrigation water.
- *Division of Water and Land Resources.* This Division's water research is carried out principally within its Catchment Hydrology Program. The aims of this program are to provide a basis for the management of catchments by developing a quantitative understanding of climate-water-land interactions at varying scales and to undertake analysis of the critical processes in catchment hydrology. It also aims to develop an understanding of hydrologic processes at the mesoscale to assist practising hydrologists with appropriate design techniques and to identify and quantify the causes of salinisation, the influence of vegetation on water quality, and, through sediment analysis, the nature and extent of long-term erosion over significant areas. Finally, the Program seeks to develop and apply remote sensing and modelling techniques to mesoscale water balance estimation.
- *Division of Chemical and Wood Technology.* Most water research undertaken in this Division is concentrated on the development of wastewater purification techniques and seeks to extend Australia's water resources through purification and recycling technology and to develop cheaper and more effective processes for the treatment of sewage and industrial effluents.
- *Other Divisions.* Research related to the various uses of water is undertaken by a number of other CSIRO Divisions: the Division of Soils, the Division of Environmental Mechanics, and the Division of Entomology, for example.

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.

Economic and Social Commission for Asia and the Pacific (ESCAP). This United Nations 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 and discussions on the main problems of water resources management in a densely populated, developing region. Australia is also an active participant in ESCAP's water information exchange system.

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

United Nations Educational, Scientific and Cultural Organization (UNESCO). Australia has contributed to the international program designed to advance the science and practice of hydrology, International Hydrology Program (IHP), through an Australian UNESCO Committee for the IHP. Australia has been elected to the Intergovernmental Council for 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 Secretary of the AWRC as hydrological advisor to the Permanent Representative of WMO in Australia, the Director of Meteorology.

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 provides a consistent global overview of changes in water quality.

Louisiana World Exposition. Australia participated in an international exposition with the theme "The World of Rivers: Fresh Water as a Source of Life" held in New Orleans, U.S.A. from May to November 1984.

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 85 per cent of the possible exploitable yield currently committed for use.

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. 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, 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 States of New South Wales, Victoria and South Australia. It also has responsibility for management of the catchment above Hume Dam and for the management of the flow of water in the Darling River below Merindee Lakes.

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 and pumping facilities by the three States. The major diversion weir is at Yarrawonga. All of the weirs except Yarrawonga have locks to enable navigation of the river to be maintained.

A new River Murray Waters Agreement, which was approved by legislation and ratified on 1 February 1984, broadens the role of the River Murray Commission to allow for more direct and independent action in the management of the Murray. The new Agreement enables the Commission to consider water quality, recreation, flood mitigation and environmental issues in relation to the management of the river system, in addition to its traditional role.

In relation to water quality, the Commission is now authorised to:

- initiate proposals for the protection or improvement of River Murray water quality
- co-ordinate or carry out investigations and studies into the feasibility of works or measures for the improved conservation and regulation of the waters of the River Murray, to protect or improve its quality
- measure and monitor water quality of the waters of the Murray and its tributaries
- formulate water quality objectives and recommend water quality standards for adoption by the Contracting Governments, and
- make recommendations to Contracting Governments or any authority, agency or tribunal on any matter which may affect the quality or quantity of the River Murray waters.

A particular feature of the new Agreement is that the State Contracting Governments are required to advise the Commission of any proposal within their States which could significantly affect the quality and quantity of the River Murray.

The new Agreement enables the Commission to clearly define the principles of water sharing laid down in the original Agreement; to enable a water accounting system to be introduced and to carry out river protection works and remedial works (including salinity mitigation works) where the need arises. The Commission can also recommend future amendments to the new Agreement.

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 254 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

The Snowy Mountains Scheme is a dual purpose hydro-electric and irrigation complex located in south-eastern Australia and on its completion was one of the largest engineering works of its type in the world. It impounds the south-flowing waters of the Snowy River and its tributary, the Eucumbene, at high elevations and diverts them inland to the Murray and Murrumbidgee rivers through two tunnel systems driven through the Snowy Mountains. The Scheme also involves the regulation and utilisation of the headwaters of the Murrumbidgee, Tumut, Tooma and Geehi rivers.

The Scheme was designed and constructed by the Snowy Mountains Hydro-electric Authority, a statutory body established by the Commonwealth Government in 1949, and was substantially completed by 1974. Its installed generating capacity is 3740 MW and its average annual electricity output is over 5000 GWh. An average of 23×10^8 cubic metres of water per year has become available for irrigation in the Murray and Murrumbidgee rivers as a result of the Scheme.

Details of the diversions and associated power works, together with details of construction, are given in Year Book No. 62, pages 444-448.

The Snowy Mountains Council, constituted of representatives of the Governments of the Commonwealth, New South Wales and Victoria and the Snowy Mountains Hydro-electric Authority, was established on 2 January 1959. Its main functions are to direct and control the operation and maintenance of the permanent works of the Snowy Mountains Scheme in particular the control of water and the allocation of loads to generating stations.

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 the 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 for farm water supply schemes, 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 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 325.

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 and Glennies Creek Dam in the Hunter Valley, 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 Chaffey Dam on the Peel River. There are a number of other smaller storages on other rivers in the State. 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 Dam, several such districts have been established along the Murray to use the New South Wales share of the stored water. The schemes are based on 'extensive' irrigation, that is, water is allocated 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.

The *Water Act, 1912* (as amended) provides for Trust Districts to be constituted 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 is Medgun, near Moree in the north-west.

CROPS AND PASTURES IRRIGATED, BY METHOD OF IRRIGATION, NEW SOUTH WALES 1983–84p
(Hectares)

	Method				
Crops and Pastures	*Sprays*	*Furrows and/or Flood*	*Trickle (a)*	*Other and multiple methods*	*Total*
Pure Lucerne	24,218	13,056	n.a.	1,084	38,358
Other pastures (sown or native)	42,647	197,635	n.a.	10,655	250,937
Wheat	9,318	72,020	n.a.	2,284	83,622
Other cereals for all purposes	20,049	121,714	n.a.	5,863	147,626
Vegetables for human consumption	8,979	3,475	187	660	13,301
Citrus fruit	3,786	3,908	1,362	207	9,263
Other fruit	1,340	1,090	4,366	301	7,097
Grapevines	1,359	5,281	1,161	119	7,920
All other crops	4,547	85,727	126	1,208	91,608
Total	**116,243**	**503,906**	**7,202**	**22,381**	**649,732**

(*a*) Includes micro-sprays.

SOURCES OF IRRIGATION WATER, NEW SOUTH WALES 1983–84p

Source of supply	*Area irrigated*	*Percentage of total area irrigated*
	(hectares)	%
Surface water		
from State irrigation schemes	372,776	57
from other schemes (including private group schemes)—		
from rivers, creeks, lakes, etc. (*a*)	217,777	34
from farm dams	20,436	3
Total surface water	*610,988*	*94*
Underground water supply (e.g. bore, spear, well) (*b*)	37,810	6
Town or country reticulated water supply	934	—
Total all water sources	**649,732**	**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 Windamere Dam on the Cudgegong River.

The construction of Split Rock Dam is under way on the Manilla River north of Manilla.

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

Work has started on the enlargement of Glenbawn Dam on the Hunter River.

Investigations are continually being carried out to assess demand and identify worthwhile water conservation projects which could be implemented as funds become available.

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 *Water Resources* in the latest edition of the New South Wales 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 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 *Water (Central Management and Restructuring) Act 1984*, abolished the State Rivers and Water Supply Commission and the Ministry of Water Resources and established the Rural Water Commission of Victoria and the Department of Water Resources. The Rural Water Commission was established to provide efficient and effective water services for the irrigation sector and other uses. The objective of the Department of Water Resources is to provide advice to the Minister on all matters relevant to the activities, or functions, of the Department to ensure that the water resources of the State are managed in ways which are most beneficial to the people of Victoria.

Works summarised

The Department of Water Resource'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 1983–84p

(Hectares)

	Method				
Crops and Pastures	*Sprays*	*Furrows and/or Flood*	*Trickle (a)*	*Other and multiple methods*	*Total*
Pure Lucerne	4,451	7,882	n.a.	193	12,526
Other pastures (sown or native)	36,282	409,016	n.a.	11,977	457,275
Cereals for all purposes	4,804	24,532	n.a.	1,533	30,869
Tobacco	2,077	53	n.a.	160	2,290
Vegetables for human consumption	13,010	3,739	145	2,216	19,110
Fruit	4,944	4,616	3,453	614	13,627
Grapevines	3,733	10,975	669	198	15,575
All other crops	1,980	3,108	79	217	5,384
Total	**71,281**	**463,921**	**4,346**	**17,108**	**556,656**

(*a*) Includes micro-sprays.

SOURCES OF IRRIGATION WATER, VICTORIA 1983–84p

Source of supply	*Area irrigated*	*Percentage of total area irrigated*
	(hectares)	%
Surface water		
from State irrigation schemes	438,913	79
from other schemes (including private group schemes)—		
from rivers, creeks, lakes, etc. (*a*)	62,148	11
from farm dams	30,128	5
Total surface water	*531,189*	*95*
Underground water supply (e.g. bore, spear, well) (*b*)	20,416	4
Town or country reticulated water supply	5,051	1
Total all water sources	**556,656**	**100**

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

Future programs

The Victorian Water Industry'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, and
- 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* 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 1926–1983*, and the *Irrigation Act 1922–1983*, 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 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 1983–84p
(Hectares)

	Method				
Crops and Pastures	*Sprays*	*Furrows and/or Flood*	*Trickle (a)*	*Other and multiple methods*	*Total*
Pure lucerne	12,453	180	n.a.	828	13,461
Other pastures (sown or native)	16,318	3,046	n.a.	2,927	22,291
Grain sorghum	3,848	5,923	n.a.	920	10,691
Other cereals (including rice)	10,969	9,842	n.a.	1,451	22,262
Cotton	959	24,195	486	267	25,907
Soy beans	6,529	7,529	n.a.	1,010	15,068
Sugar cane	50,722	43,671	467	9,353	104,213
Vegetables for human consumption	14,820	3,103	948	1,344	20,215
Fruit (including grapevines)	3,385	210	4,050	812	8,457
All other crops	6,426	1,916	244	796	9,382
Total	**126,429**	**99,615**	**6,195**	**19,708**	**251,947**

(*a*) Includes micro-sprays.

SOURCES OF IRRIGATION WATER, QUEENSLAND 1983–84p

Source of supply	*Area irrigated*	*Percentage of total area irrigated*
	(hectares)	%
Surface water		
from State irrigation schemes	54,948	22
from other schemes (including private group schemes)—		
from rivers, creeks, lakes, etc. (*a*)	43,629	17
from farm dams	39,028	15
Total surface water	*137,605*	*55*
Underground water supply (e.g. bore, spear, well) (*b*)	113,338	45
Town or country reticulated water supply	1,003	..
Total all water sources	**251,947**	**100**

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

Irrigation areas

About 25 per cent of the area under irrigation annually, i.e. some 75,230 hectares, is concentrated in seven Irrigation Areas constituted under the *Irrigation Act 1922–1983*, 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. 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 and small crops and urban supplies for Bundaberg and adjacent shires; Fred Haigh Dam.
Eton	Hinterland of Mackay; sugar cane; Kinchant Dam.

A number of other schemes have been established under the *Water Act 1926–1983*, 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 1978–1984* 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 331 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, 1983*, 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 Irrigation Areas. 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 Bolivar 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

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).

CROPS AND PASTURES IRRIGATED, BY METHOD OF IRRIGATION, SOUTH AUSTRALIA 1983–84p

(Hectares)

Crops and Pastures	Method				
	Sprays	*Furrows and/or Flood*	*Trickle(a)*	*Other and multiple methods*	*Total*
Pure Lucerne	10,976	4,324	n.a.	469	15,769
Other Lucerne-based pastures	2,689	1,126	n.a.	117	3,932
Other pastures (sown or native)	11,651	14,228	n.a.	999	26,878
Cereals for all purposes	1,591	807	n.a.	109	2,507
Vegetables for human consumption	5,485	336	129	530	6,480
Fruit	7,156	1,323	3,103	818	12,400
Grapevines	5,950	6,888	3,930	1,149	17,917
All other crops	1,179	877	32	55	2,143
Total	**46,677**	**29,909**	**7,194**	**4,246**	**88,026**

(*a*) Includes micro-sprays.

SOURCES OF IRRIGATION WATER, SOUTH AUSTRALIA 1983–84p

Source of supply	*Area irrigated*	*Percentage of total area irrigated*
	(hectares)	%
Surface water		
from State irrigation schemes	17,233	20
from other schemes (including private group schemes)—		
from rivers, creeks, lakes, etc. (*a*)	19,672	22
from farm dams	3,710	4
Total surface water	*40,615*	*46*
Underground water supply (e.g., bore, spear, well) (*b*)	44,625	51
Town or country reticulated water supply	2,786	3
Total all water sources	**88,026**	**100**

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

Adelaide Metropolitan Water Supply

In 1983–84, River Murray pipelines supplied 37 per cent of the total intake to the Metropolitan Adelaide Water Supply System. This compared with 1982–83, a year of severe drought, when 85 per cent (the highest ever recorded) was supplied from the River Murray. The principal sources of supply for the nine 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", South Eastern 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. Disposal of drainage water is achieved by pumping to basins on river flats where it is evaporated, or by discharge into the river when it is in flood—apart from those areas connected to the Noora Drainage Disposal Scheme. This scheme is the central feature in a $25 million package of six salinity control measures commenced in 1979 following investigations into alternative disposal schemes. The package includes engineering works, improved irrigation practices and river regulation to reduce salinity to acceptable levels.

The Noora Scheme allows drainage water formerly held in river flat basins to be pumped to a large evaporation basin located well out of the river valley at Noora, approximately 20 km east of Loxton. The first stage of the scheme, pumping from Berri, was commissioned in September 1982, the second (Dishers Creek) stage in February 1983, and the final (Renmark) stage in July 1984.

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 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. He also 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.

Irrigation areas at Carnarvon and on the Ord and Fitzroy Rivers in the Timor Sea Drainage Division are established in the north of the State.

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 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 171 properties with 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. The main crops being grown at present are rockmelons, sorghum, pumpkins, maise and soyabeans. Other crops grown include watermelons, cucumbers, bananas, hay, peanuts and sunflowers. 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'. A small area is being cropped.

CROPS AND PASTURES IRRIGATED, BY METHOD OF IRRIGATION, WESTERN AUSTRALIA 1983–84p
(Hectares)

	Method				
Crops and Pastures	*Sprays*	*Furrows and/or Flood*	*Trickle (a)*	*Other and multiple methods*	*Total*
Pure Lucerne	908	594	n.a.	101	1 603
Other pastures (sown or native)	1,871	13,310	n.a.	437	15,618
Cereals for all purposes	409	968	n.a.	28	1,405
Vegetables for human consumption	2,945	481	192	470	4,088
Fruit	1,481	403	1,604	262	3,750
Grapevines	23	10	144	12	189
All other crops	413	1,015	327	62	1,817
Total	**8,050**	**16,781**	**2,267**	**1,372**	**28,470**

(*a*) Includes micro-sprays.

SOURCES OF IRRIGATION WATER, WESTERN AUSTRALIA 1983–84p

Source of supply	*Area irrigated*	*Percentage of total area irrigated*
	(hectares)	%
Surface water		
from State irrigation schemes	11,864	42
from other schemes (including private group schemes)—		
from rivers, creeks, lakes, etc. (*a*)	2,168	8
from farm dams	4,832	17
Total surface water	*18,864*	*66*
Underground water supply (e.g., bore, spear, well) (*b*)	5,270	19
Town or country reticulated water supply	4,337	15
Total all water sources	**28,470**	**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 90 towns and 2.7 million hectares of farmland.

West Pilbara Water Supply. The West Pilbara Water Supply serves consumers in the towns of Dampier, Karratha, Roebourne, Wickham and Point Samson and industrial complexes at Dampier, Cape Lambert and the Burrup Peninsula. Water is supplied from the Millstream groundwater source. Future augmentation will be from the Harding Dam which is at present under construction.

Geraldton Regional Water Supply. The Geraldton Regional Water Supply is supplied principally from the Allanooka groundwater source and a small amount from Wicherina (groundwater plus catchment). Towns supplied are: Geraldton, Denison, Mullewa, Dongara, Walkway, Narngulu and Eradu.

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 32 towns and 0.6 million hectares of farmland.

Port Hedland Water Supply. The Port Hedland Water Supply supplies Port Hedland, South Hedland and Wedgefield from the Yule River and De Grey groundwater sources.

The Mandurah Regional Water Supply. This scheme obtains supplies from the South Dandalup Dam and the Ravenswood groundwater source. Towns supplied are Mandurah, Yunderup, Furnissdale, Coodanup, Riverside Gardens and Ravenswood. Extension of the scheme to localities north and south of Mandurah is in progress.

MAJOR WATER SUPPLY SCHEMES
COMPARATIVE PUMPING STATISTICS FOR PAST YEARS
(millions of cubic metres)

	1979-80	*1980-81*	*1981-82*	*1982-83*	*1983-84*
Goldfields and Agricultural Areas Water Supply	23.61	25.43	24.70	26.28	29.83
West Pilbara Water Supply	9.39	9.81	10.50	11.46	11.00
Geraldton Regional Water Supply	6.97	7.43	7.20	7.31	6.88
Great Southern Towns Water Supply	6.49	6.19	5.88	6.72	5.72
Port Hedland Water Supply	6.00	5.97	5.78	6.07	5.03
Mandurah Regional Water Supply	1.83	1.94	2.11	2.75	3.18

Local and Other Regional Water Supplies. As well as the major water supply schemes above, water is also supplied by the Government from 8 other Regional Water Supply Schemes to 21 towns and from 102 local water supply schemes to 103 towns. The water comes from a variety of sources including underground, artificial catchments and stream flows.

Aboriginal Communities Water Supplies. Work has commenced on a program to upgrade the water services of remote Aboriginal communities. The program involves providing a town level of service to 40 communities and a basic level of service to 30 outstations. Water for these supplies will come predominantly from underground sources, with only one community being supplied from a river flow and another from an artificial catchment. Investigations and design work has largely been completed and construction work has commenced. Services to 7 communities will be completed by the end of 1984-85.

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 Minister may approve the 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 40,220 hectares irrigated in the State in 1983-84 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 other vegetables amount to 33 per cent of the total area irrigated.

CROPS AND PASTURES IRRIGATED, BY METHOD OF IRRIGATION, TASMANIA 1983-84p

(Hectares)

	Method				
Crops and Pastures	*Sprays*	*Furrows and/or Flood*	*Trickle (a)*	*Other and multiple methods*	*Total*
Pure Lucerne	873	61	n.a.	23	957
Other pastures (sown or native)	9,212	7,937	n.a.	715	17,864
Cereals for all purposes	1,453	101	n.a.	114	1,668
Potatoes	3,915	51	7	772	4,745
Other vegetables for human consumption	7,129	45	16	1 212	8,402
Fruit	1,120	53	843	150	2,166
All other crops	3,761	283	5	369	4,418
Total	**27,463**	**8,531**	**871**	**3,355**	**40,220**

(*a*) Includes micro-sprays.

SOURCES OF IRRIGATION WATER, TASMANIA 1983-84p

Source of supply	*Area irrigated*	*Percentage of total area irrigated*
	(hectares)	%
Surface water		
from State irrigation schemes	2,381	6
from other schemes (including private group schemes)—		
from rivers, creeks, lakes, etc. (*a*)	15,701	39
from farm dams	20,077	50
Total surface water	*38,159*	*95*
Underground water supply (e.g., bore, spear, well) (*b*)	1,658	4
Town or country reticulated water supply	403	1
Total all water sources	**40,220**	**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

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.

Northern Territory water legislation is under review. It is proposed that the above mentioned Acts will be amalgamated into a new 'Water Act' in *1985*.

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 and operation of town water supplies, management of water resources throughout the Territory 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 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 17,000 bores and wells registered in the Territory up to 30 June 1984, 40 per cent were for pastoral use, 20 per cent were investigation bores, 20 per cent served town and domestic supplies, 3 per cent were for crop use, 10 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, Jabiru and Nhulunbuy, are supplied from groundwater.

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 stream gauging 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.

Irrigation in the Territory is not extensive, being confined to isolated locations near Darwin, Adelaide River, Daly River, Katherine, 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.

There is increasing demand for water resources assessment studies and assistance for relatively small irrigation projects.

Australian Capital Territory

Surface water

Surface water storages supplying Canberra (population about 240,000) 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). The storage to the south-east is in New South Wales in the Queanbeyan River catchment (over which the Commonwealth has permanent water rights) on the western slopes of the Great Dividing Range is the Googong Dam (125 million cubic metres).

The existing storages on the Cotter and Queanbeyan rivers 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 and maintained by the Department of Housing 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 1950s and until 1978 maintained a network of 48 observation bores which had been 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.

Control of irrigation and farm water supplies is exercised by the Department of Territories and Local Government. The Bureau of Mineral Resources of the Department of Resources and Energy provides technical advice to landholders and drilling contractors on groundwater and, occasionally, on runoff.

BIBLIOGRAPHY

Review of Australia's Water Resources, Department of National Development and Energy, Australian Water Resouces Council, Canberra, 1975.

National Survey of Water Use in Australia, Department of National Development and Energy, Australian Water Resources Council, Occasional Paper Series No. 1, AGPS 1981.

Water 2000, Department of Resources and Energy, Canberra, 1983.