PUBLIC WORKS DEPARTMENT
WESTERN AUSTRALIA

WATER SUPPLIES
&
IRRIGATION

This publication is intended for use by students and others interested in the supply of water to country towns and country areas of Western Australia

The information contained herein covers the subject briefly. It is divided into three sections :

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SECTION 1

GOLDFIELDS, COUNTRY TOWNS AND AGRICULTURAL AREAS WATER SUPPLIES

The construction and maintenance of water supplies for towns and agricultural areas outside the Perth Metropolitan area is the responsibility of the Public Works Department of Western Australia.

These Water Supplies fall naturally into three main groups viz:

Group 1	Those whose principal source of supply is Mundaring Reservoir near Perth.
Group 2	Those whose principal source of supply is Wellington Dam near Collie.
Group 3	Those whose entire supply is obtained from local sources such as small reservoirs or underground supplies.

TOWNS AND AGRICULTURAL AREAS SUPPLIED FROM MUNDARING RESERVOIR

The scheme which uses Mundaring Reservoir as its source is now known as the Goldfields and Agricultural Water Supply Scheme. The present Scheme came into being under the guidance of Sir John (later Lord) Forrest, Premier of the State and the then Engineer in Chief, Mr. C.Y. O'Connor, to supply the needs of the large Gold Mining communities at Coolgardie, Kalgoorlie and Boulder. This scheme which cost $5,732,908 was opened in 1903, involved the building of the Mundaring Weir, the construction of pipe line 30 inches in diameter and 346 miles in length, and the provision of 8 steam driven Pumping Stations along the pipe line, to deliver water to Kalgoorlie and other towns en route.

Following the decline of the gold mining industry, subsequent to 1911 and the rapid development of the wheat belt on both sides of the Eastern Goldfields Railway between Northam and Southern Cross, extensions from the Goldfields main conduit were made to supply water to agricultural lands and townships.

Today there are over 4.6 thousand miles of branch and reticulation mains supplying water to approximately 6.2 million acres of farmland and 112 towns and localities. Work in hand under a scheme called the Comprehensive Water Supply Scheme will increase the area served to over 7¾ million acres. Peak summer consumption on the Goldfields is now about 10 million gallons per day, and about 16 million gallons per day on the rest of the system.

To meet the increasing demand for water, particularly from the mining industry, it has been necessary to enlarge the Goldfields main conduit over vital sections and to install more powerful pumping machinery in some pumping stations.

MUNDARING RESERVOIR

Mundaring Reservoir situated on the Helena River 26 miles east of Perth is the source of supply for the Goldfields and Agricultural Water Supply. The original Weir completed in 1902 was a concrete gravity type 100 feet high, 755 feet long with a capacity of 4,655 million gallons. The wall at the bottom was 85 feet thick and at the top 11 feet.

In 1951 the height was increased to 132 feet. This increased the reservoir capacity to 15,154 million gallons, the length of the wall to 1,010 feet and the thickness at the lowest offtake level to 107 feet. With crest gates raised, the capacity is now 16,966 million gallons. The Catchment area of the reservoir is 569 square miles. When the reservoir is full the water extends back some 10 miles from the wall and covers an area of 1,880 acres. There are 162 thousand cubic yards of concrete in the wall.

MAIN CONDUIT

The length of the Main Conduit from Mundaring Reservoir to Kalgoorlie is 344 miles. It is laid in duplicate for 51 miles bringing the total length of pipes in service to 395 miles. The diameter varies between 48 inches and 24 inches. The original pipe line consisted of 28 feet sections of 30 inch diameter pipes buried in the ground. Extensive alterations and enlargements have been made in recent years. The original pipes with lead joints, which became very costly to maintain have been replaced by pipes with continuously welded joints. They have been relaid on concrete blocks above ground to minimise external corrosion, and they have been lined internally with concrete to prevent internal corrosion.

During the early 1930's replacement renovations to 39 miles of main were made with 24" and 30" karri wood stave pipes for economic reasons. All of this woodpipe has been replaced with steel pipe.

PUMPING STATIONS ALONG THE MAIN CONDUIT

Water from Mundaring Reservoir is pumped by means of 16 Pumping Stations placed along the main conduit. The scheme as completed in 1902, contained 8 steam driven Pumping Stations. Over the years, the water demand on the system has increased and it has been necessary to replace the original pumping stations with more powerful machinery.

By 1960, after more than 50 years of service, four of the original Steam Driven Pumping Stations were replaced with three electrically driven Stations. Those replaced were Mundaring (Nos. 1 and 2) Cunderdin (No. 3) and Merredin (No. 4).

Because of the greater lifting power of the electrically driven centrifugal pump it was possible to eliminate the old No. 2 Station. Yerbillon (No. 5) Pumping Station was replaced in 1968. No. 6 and No. 7 were replaced with a single electric station at Ghooli in 1969 and Dedari (No. 8) Station with diesel driven units in the same year.

Eleven additional Pumping Stations which operate only in the summer months have been constructed at Chidlow, Wundowie, Grass Valley, Meckering, Kellerberrin, Baandee, Walgoolan, Southern Cross and Koorarawalyee, Bullabulling, and Lower Helena.

Total installed Horse Power 33,000.

The total quantity of water pumped from Mundaring Weir Pumping Station to the scheme has increased from 1,846 million gallons in 1937-38 to 5,130 million gallons in 1971-72.

TANKS Since 1950 storage reservoirs constructed on the Goldfields line have been :-

KALGOORLIE	- Two 25 million gallon storages			
MERREDIN	- One 25	"	"	"
DEDARI	- One 12	"	"	"
NORSEMAN	- One 10	"	"	"
WEST KELLERBERRIN	- One 5	"	"	"
BOORAN	- One 2	"	"	"
GHOOLI	- One 2	"	"	"

The completion of these storages has increased the total reserve and operating storage to 227 million gallons. This has ensured the continuity of supply in the event of a breakdown in the main conduit and/or its associated pumping stations. The storages also enable the system to meet the demands of a series of excessively hot days without having to resort to temporary restrictions.

SERVICES

The total number of services now connected is about 26,500.

CAPITAL COST

The total cost of the scheme as constructed in 1903 was ($5,732,908). The total capital expenditure now exceeds $50,000,000.

TOWNS AND AGRICULTURAL AREAS SUPPLIED FROM WELLINGTON DAM

The scheme which uses Wellington Dam as its source of supply is the Great Southern Towns Water Supply Scheme.

WELLINGTON DAM

Wellington Dam is situated on the Collie River west of the coal mining town of Collie. It was originally constructed in 1933 to supply water for the Collie Irrigation District on the rich flats between Harvey and Brunswick. It was a concrete gravity type dam with a wall some 800 feet long and 62 feet high containing 33,000 cubic yards of concrete. It had a capacity of 6,900 million gallons. Between 1955 and 1960 the dam was raised 50 feet in height to increase its storage to 40,790 million gallons. Some 85,000 cubic yards of concrete were used and the total cost was $2,764,000. The catchment area is 1,115 square miles.

Following the natural rock foundation the wall rises majestically to a height of 112 feet and is built in the shape of a broad vee, the apex of which faces upstream.

A 2,000 kilowatt hydro-electric generating set has been installed below the dam. It operates during the summer when water for irrigation is being discharged from the dam, and during periods of excess river flow in the winter. The hydro-electric set feeds into the State Electricity Commission's grid system.

WELLINGTON DAM TO NARROGIN PIPELINE

The Wellington Dam to Narrogin Pipeline was constructed between 1949 and 1956 to supply water from Wellington Dam to the towns along the Great Southern Railway between Brookton, Katanning and Broomehill and the associated farmlands en route.

It is a 30 inch diameter continuously welded cement lined steel pipe eighty miles in length and laid generally above ground. There are three electrically driven pumping stations situated at Wellington Dam, Collie and Bingham River.

BRANCH MAINS

A branch main 18 inches in diameter supplies water to the State Electricity Commission's power station at Muja which is situated within the Collie coalfield area.

The Wellington to Narrogin Pipe Line terminates at Bottle Creek Reservoir near Narrogin. From this Reservoir water is pumped to the north as far as Brookton, to the east to Kulin, Dumbleyung and Bullaring and to the south to Katanning, Gnowangerup and Kojonup. Thirty towns and localities and 1,480,000 acres of farmland are supplied with water from this scheme.

THE COMPREHENSIVE WATER SUPPLY SCHEME

Agricultural Development

Prior to the opening of the Goldfields Water Supply Scheme in 1903 the development of the agricultural areas of Western Australia was slow and hesitant, being confined to limited areas, around such towns as Northam, York, Narrogin and Katanning. Under the impetus of the increasing population, improved farming techniques, and sympathetic governments, agricultural development proceeded quickly, after 1903, and the settled area soon spread along the Great Eastern Goldfields Railway, as far as Merredin.

The Railway and the Goldfields and Agricultural Water Supply Main Conduit traverse the centre of an area which has proved to be of the richest mixed farming (sheep and cereals) areas in the state. Rainfall in the area occurs almost wholly in the winter months the summers being long and dry. It is fairly reliable for crop growing purposes, but the watering of large flocks of sheep during the summer months presents many problems.

In 1907 the construction of a branch main north of Tammin (the first of many) demonstrated to the farmers and to the State, the value of assured and adequate water supplies for stock and domestic purposes. By 1947 some 800 miles of such branches had been laid bringing water security to nearly 1,000,000 acres of farmlands.

In 1946 the State Government prepared a Scheme which has become known as the Comprehensive Water Supply Scheme to supply water to some 11.6 million acres of farmlands. The Commonwealth Government of the day appointed an interdepartmental committee to report on the proposed Scheme. That Committee reported that certain areas had greater priority, and as a result a Modified Comprehensive Scheme was designed to serve an area of 4.1 million acres of farmlands as well as towns along the Great Southern Railway.

The Modified Comprehensive Scheme provided for the extension of branch mains from the main Goldfields pipeline to serve farmlands and towns with water from Mundaring Weir near Perth, and provided for the construction of the Wellington Dam to Narrogin Pipeline and branch mains to serve Brookton in the North and Katanning in the South. The total cost of the Modified Scheme was $20,400,000 and was subsidised on a $ for $ basis by the Commonwealth Government. It was completed in 1961.

Between 1962 and 1965 the State Government proceeded with the construction of further extensions within the boundaries of the original (1946) proposals. It extended mains to serve the towns of Dalwallinu, Wongan Hills, Kojonup, Gnowangerup and Wickepin. In December 1964 the Commonwealth agreed to further assist the State Government (by way of interest free loans) to extend both the Goldfields and Agricultural Water Supply and the Great Southern Towns Water Supply to serve an additional 3.7 million acres. This work is estimated to cost $29,500,000 and is being carried out over a seven year programme which is due for completion this year.

WATER SUPPLIES FOR COUNTRY TOWNS OTHER THAN THOSE SUPPLIED FROM MUNDARING RESERVOIR OR WELLINGTON DAM

In its efforts to provide reliable water supplies for country centres the Public Works Department investigates any suitable source of supply and has developed schemes based on a variety of diversified sources. Supplies are derived from bores, wells, unused mine shafts, rivers, irrigation channels or from excavated dams fed by natural earth or rock catchments and bitumen covered or roaded artificial catchment.

The Department supplies water to 128 towns and localities, maintains stock route wells throughout the State, Roadside watering points along Eyre Highway and emergency key dams in the lighter rainfall areas outside the comprehensive scheme. The direct cost of maintaining these supplies is in the region of $2,600,000 a year.

Important new water supplies have been developed in the Geraldton region where extensive geological surveys were carried out to locate suitable underground sources. A scheme based on pumping from deep bores at Arrowsmith has been developed to supply Morawa and later extended to Perenjori.

Thirty five miles south east of Geraldton in the vicinity of Lake Allanooka a system of bores was put down into a vast underground source. Each bore yields 20,000 gallons of good quality water per hour. The water is pumped from the bores through 2½ miles of 24 inch diameter steel main to a five million gallon concrete summit tank 416 feet above sea level.

From this tank the water gravitates through 31 miles of 24 inch pipeline to a high level 2 million gallon service tank at Geraldton and into the town's reticulation system.

The scheme also supplies Dongara, Denison, Narngulu and Walkaway.

The project cost $2,475.000 and took 2½ years to complete.

Stage one of an important new scheme has been completed to serve the mining towns of Dampier and Karratha in the West Pilbara area. The scheme came into operation when the first water reached Dampier on October 25, 1969.

The project was designed to pump 3 million gallons per day from bores at Millstream through 84 miles of steel pipe ranging from 24 to 15 inches in diameter. The work was constructed as a result of an agreement with Hamersley Iron Pty. Ltd. who arranged the construction in accordance with departmental design and specifications.

A duplicate main to serve Cape Lambert and Wickham is substantially complete.

The enlarged scheme is designed to deliver 7 million gallons per day.

SECTION 2

IRRIGATION

SOUTH WEST DISTRICTS

The irrigation area provided with permanent water storages and distribution is situated between Waroona seventy miles south of Perth and Dardanup one hundred and sixteen miles south of Perth. This area which occupies a belt of coastal plain seven miles wide contains three irrigation districts named Harvey, Collie River and Waroona.

The cost of provision of capital works is accepted as the responsibility of the State and water is supplied to privately owned farms which have followed a free pattern of development. Irrigators pay the cost of maintenance and operation of the systems in the form of rates and charges.

Construction of works, maintenance and operation are undertaken by the Public Works Department. The Minister for Works and Water Supplies is advised by an Irrigation Commission under the Rights in Water and Irrigation Act.

The Department of Agriculture is responsible for irrigation research and provision of agricultural advice to farmers. In addition good farming practice is further enhanced by the use of private group Agricultural Advisers.

Although the established irrigation area has an average rainfall of forty inches, the bulk of the rain falls between the months of May and September, inclusive, and little or no rain falls between the summer and early autumn months of December to March. The monthly average rainfall during the summer is only half an inch.

As a result of drainage of the coastal flats the development of a valuable winter agricultural system had already occurred prior to irrigation but the application of irrigation water to the belt of the coastal flats during the hot, dry, summer months improved agricultural production to a marked degree.

Irrigation was commenced in 1916 with the opening of the Harvey Dam, a concrete gravity wall with a capacity of 500 million gallons, provided by the State to serve 3,000 acres of privately owned citrus growing land with three four inch waterings each season for the whole of the area.

Owing to the failure of citrus production interest turned to dairying, with good results. A move towards improvement of pasture and a demand for more water followed. An increase in reservoir capacity to 2,275 million gallons was provided in 1931. An additional 14,000 acres, known as the Harvey No. 2 District with 1 acre in three irrigated were included in the scheme.

At that time also the State considered the advisability of providing irrigation facilities for Waroona, to the North, and for the area between Roelands and Dardanup to the South of Harvey.

In July 1931 an earth-fill dam 54 feet high and 580 feet crest length was completed across Drake's Brook, near Waroona. With a capacity of 504 million gallons and availing itself, as did the other dams, of available summer inflow, it was to serve 9,600 acres in the Waroona Irrigation District, one acre in three and a half of farm area being irrigated.

In order to supply the Roelands-Dardanup area, to be known as the Collie River Irrigation District, Wellington Dam, a gravity type concrete wall across the Collie River was completed in 1933. This wall was raised by three feet in 1944 to provide a capacity of 8,700 million gallons to supply 28,000 acres of land at one acre in three.

During this early period much research and experimental work had been done by the Department of Agriculture and in consequence the original allotment of water of one acre foot had been increased by 1935 to two and a half acre feet per irrigated acre per year on a 21 day cycle with an additional allowance of one and a quarter acre feet per acre per year for distribution, seepage and evaporation losses. Depending on favourable seasons, water above the allotment was available for sale as accommodation water and used principally for germination of early winter feed.

In 1941 the construction of an earth and rock fill dam with a height of 100 feet, crest length 797 feet and capacity 1,777 million gallons, later increased by flash-boards was completed across Samson Brook to augment supplies to the Waroona Irrigation District.

In 1948 construction of Stirling Dam across Harvey River upstream of Harvey Weir, was completed. This earth and rock fill dam, with a maximum height of 152 feet, crest length of 900 feet and capacity of 12,060 million gallons, later slightly increased by flash boards, was built to augment the supply to Harvey Irrigation District. It also extended irrigation to the area between Harvey and the Waroona District and later as far south as the Collie River District.

Wellington Dam wall was raised fifty feet, to a height of 112 feet, in 1960 to augment supplies to Collie River Irrigation District, and to provide for 9,000 acres of extension with 1 acre in 3 irrigated. The storage provides 55,000 acre feet of water for irrigation.

For further augmentation of supply to Harvey Irrigation District, Logue Brook Dam, an earth-fill structure, of capacity 5,358 million gallons, height 148 feet, and crest length 1,100 feet was completed in 1963.

Waroona Dam was constructed in 1966 on Drake's Brook to further augment the irrigation supplies to the Waroona District. This earth-fill Dam has a crest length of 1,249 feet, height of 119 feet and a capacity of 3,290 million gallons.

All water is supplied by gravity to the farm boundaries in open channels. The bulk of the land is watered by border method or furrow method of irrigation now largely on an 16 day cycle. Approximately 1,000 acres only are under sprinklers. An appreciable amount of land is graded each year with machine land graders.

Transit losses of water are continually under investigation and distribution systems are being improved progressively. The Department of Agriculture is undertaking current investigations into the economy of use of water.

Originally water supplied was measured as wetted area so that irrigation was confined to fixed positions on a farm but Dethridge Wheel meters are now accepted for volumetric gauging of supplies to irrigationists and progressive installation of these meters throughout the District is in hand.

The State Department of Agriculture provides an extension service to advise irrigationists on agricultural matters.

The annual rate for irrigation water in the Waroona and Harvey districts is $7.60 per irrigated acre. This rate entitles the irrigationist to 2 acre feet of water. Subsequent supplies of water are charged at $3.80 per acre foot. In the Collie district shorter watering periods are being tried with corresponding higher charges.

Surface drainage is an important pre-requisite to irrigation and is an additional cost to that of irrigation.

The 1969/70 irrigation season was a record one in the length of season and quantity of water used. This was due to a long dry summer following a winter with virtually no rain in the later months. 34,938 acres were watered an average of 7.6 times using 136,663 acre feet of water whereas in 1970/71 34,225 acres were watered an average of 6.6 times using 118,949 acre feet of water. Nearly ninety-nine percent of the area watered was used for permanent pasture, fodder and early germination, principally for whole-milk production. The remaining production was comprised of potatoes, vegetables, and orchards.

When the three districts are fully developed a total "irrigable area" of 31,652 acres in a combined District area of 87,865 acres will be provided with a reliable allotment of irrigation water. Additionally, accommodation water will be available for sale for a variable area.

The total irrigation capital expenditure in the three Districts was $13,711,666 to June 30, 1971 giving a unit cost of $156.00 per acre of District.

PRESTON VALLEY IRRIGATION

Glen Mervyn Dam was built to provide irrigation water to established orchards and farms in the Preston Valley, because the natural supply in the Preston River was usually so diminished by late summer that partial irrigation only was possible. As a result in the past there have been considerable seasonal fluctuations in yield and quality of crops, thus preventing maximum economic return.

The dam was completed in May 1969 and has a capacity of 1,209 acre feet or 329 million gallons. The catchment area is 13.1 square miles.

The scheme originally supplied 30 properties between Mumballup and Donnybrook but was extended in 1971 and 1972 to serve an additional 15 properties downstream of Donnybrook. As the river flow drops, water is released from the dam and orchardists pump from the river onto their properties through Departmental meters. The current charge is $15 per acre foot.

CARNARVON IRRIGATION DISTRICT

The irrigation area comprises some 150 plantations within 10 miles of the mouth of the Gascoyne River. Most of the properties have a river frontage and are about half a mile deep. The properties total 5,000 acres with an irrigated area of approximately 2,000 acres.

Water is drawn from the river sands and from a relatively shallow aquifer under and adjacent to the river, by individual farmers pumping from bores or wells on, or in front, of their properties. An irrigation scheme operated by the Public Works Department draws water from further upstream and supplements the supply to 49 plantations. This scheme is being progressively extended.

The aquifers are recharged by flows in the Gascoyne River which unfortunately are irregular and unpredictable. Situated between the tropics and temperate zone, the catchment receives neither the regular monsoonal rains of the former nor the winter rainfall of the latter. The annual 7 to 8 inch average comes mainly from infrequent tropical storms extending further South than usual or from the fringes of extensive Southern winter storms.

Irrigation in the Carnarvon Area commenced in the early 1930's but it was not until the early 1950's that a sharp rise in production occurred. This sudden increase, the resultant demand and the uncontrolled draw of irrigation water from the Gascoyne delta sands seriously depleted reserves and resulted in many areas in an increase in ground water salinity. The problem was accentuated by the lack of a river flow to replenish the aquifers between March 1955 and February 1957. As a result of grower representations, the Government introduced control measures in December 1959 to limit the rate of pumping from the Gascoyne River Sands. In 1961 the Irrigation Scheme was commenced as a Pilot Scheme to augment the water supplies of plantations on the South Bank of the river when the water shortage and salinity problem were most acute. The current charge for Departmentally supplied water is $15 per acre ft.

Since the introduction of controls, a succession of favourable seasons with at least one good river flow each year, has enabled fairly liberal water allocations. Improved irrigation techniques and a general appreciation of the value of water have enabled the irrigated area to expand to about 2,000 acres (approximately 600 acres of bananas and 1,400 acres of vegetables) with an average water usage of 25 million gallons per week. Prior to controls, an average of 35-40 million gallons per week was used to irrigate approximately 880 acres.

ORD IRRIGATION PROJECT

The Ord Irrigation Project in the Kimberley region of Western Australia is the boldest move yet made to develop the nation's tropical north for intensive agriculture. It involves harnessing the water of the Ord River and storing it in dams to irrigate 178,000 acres of potentially rich plains in an area now devoted largely to open range cattle grazing. Two-thirds of the irrigable area lies in Western Australia, the remainder in the Northern Territory.

In 1963 Kununurra Diversion Dam was completed on the Ord River, some 65 miles south-east of Wyndham, the State's most northerly town. Besides diverting water onto the irrigation area, the dam also stored 80,000 acre feet of water when full. The Ord River Dam 30 miles upstream of the Kununurra Diversion Dam was commenced in 1969 and began storing water on 13th November, 1971 at the start of the 1971/72 "wet" season. The reservoir formed will cover 286 square miles and will impound 4,600,000 acre feet. It will be one of the biggest man-made storage reservoirs in Australia and at spillway level will contain over nine times the water in Sydney Harbour. The dam cost some $21.6 million. Associated irrigation works to be built over a number of years will cost an additional $27 million.

The project is regarded as the initial step in what could be a grand design to harness other northern rivers, relieving the present dependence on a harsh land with long dry seasons between summer rains. During the northern wet season from December to April each year, the Ord and other Kimberley Rivers are often gorged with monsoonal floodwaters. During peak floods, the waters of the Ord have flowed north into Cambridge Gulf at the rate of more than a million cubic feet a second. When the wet season ends the great rivers stop running and the lush seasonal pastures wither and die.

The potential for harnessing northern rivers was realised many years ago and the Ord Irrigation Project is a result of careful investigation and planning. In 1941 a small experimental farm was established on the Ord near Wyndham and possible dam sites were investigated upstream. In 1945 this small experimental farm was abandoned and the Kimberley Research Station was established some 12 miles downstream on Ivanhoe Plain - part of the 30,000 acre area now irrigated from the Kununurra Dam - as a joint Commonwealth-State venture.

Crop trials were carried out over 12 years and it was found that cotton, safflower, linseed and sugar cane would flourish in the area under irrigation. In 1958 the West Australian Government was satisfied that an irrigation scheme on the Ord would work. The Federal Government agreed to share the cost of the Kununurra Diversion Dam and this was completed in 1963. The total cost of the dam and associated works was some $20 million - of which the Commonwealth contributed two-thirds.

By 1966 the 31 farms irrigated from the Kununurra Diversion Dam had been allocated - their average size, 660 acres. Cotton grown on them is processed in two ginneries, baled and road-freighted to Wyndham for export. A new township, Kununurra, was built to serve the scheme. By the time the Scheme is fully developed, Kununurra will be the largest town in the Kimberley. Planners envisage an eventual population of 20,000 in the Ord Valley.

The main crop on the land irrigated from the Kununurra Diversion Dam has been cotton. In 1972, 9,700 acres of cotton produced an average yield of 810 lbs of lint cotton per acre which due to seasonal conditions was lower than the 1971 record of 960 lbs per acre.

3,600 acres of other crops including fodder crops, pasture and and grain sorghum for cattle fattening were grown in 1970/71 and the area of fodder crops is increasing. Trial crops of peanuts and safflower were also included.

The current annual rate for water is $3.00 per acre entitling the irrigator to 1 acre foot of water. Subsequent supplies are charged at $3.00 per acre foot.

Increasing yields and financial returns to the original settlers soon established that the scheme was a success, and in 1967 the Commonwealth Government agreed to provide finance for the Ord River Dam. This is of rockfill construction. During peak floods the dam's capacity may increase from 4,600,000 acre feet at spillway level up to its maximum flood storage of 31,200,000 acre feet spreading over 850 sq. miles. Although the maximum flood storage is not expected to be reached more than once in 10,000 years the level of the dam will for most of its life be above the spillway level because of its huge flood storage capacity.

Water from the Ord River Dam will keep the Kununurra Diversion Dam full so that it can flow into the irrigation channels by gravity. When the scheme is complete, primary production from the areas sown to irrigated crops is expected to be worth in the order of $30,000,000 a year.

The cattle industry, now the most important in the Kimberley, is also expected to benefit from the scheme. At present the cattle are run on properties up to a million acres in size without the benefit of supplementary feeding. There are heavy losses among breeders toward the end of the dry season. These losses are expected to be reduced by feeding protein meal to the stock during the critical period. This could be made from cotton seed, linseed or safflower after the oil has been extracted. Grain sorghum is another crop which grows well in the Ord alley and which has great potential either as stock fodder or grain for export. In addition, cattle fattening by feedlots in the irrigation area has already commenced and is expected to become a major part of the cattle industry in the East Kimberleys.

CAMBALLIN IRRIGATION AREA

In 1951 the first attempt at irrigation in the West Kimberleys was made at Camballin by Mr. K.M. Durack who set up a small property on behalf of Northern Developments Pty. Ltd., some 75 miles from Derby. Following success with rice growing, the Company in 1957 entered into an agreement with the State Government providing for the progressive development of an area of 20,000 acres.

The State Government invested approximately $2,000,000 in the construction of a small storage and diversion scheme from the Fitzroy River. Irrigation water is diverted from the river by a barrage which is equipped with 48 steel shutters each 8 ft. by 6 ft., capable of collapsing automatically in flood time.

The stream flow of the river is diverted into the improved natural channel of Uralla Creek leading to the 17 Mile Dam storage of 4,400 acre feet capacity. There is insufficient water for large scale dry season cropping. Up to 1,200 acres of wet season rice was grown with disappointing results.

A problem with the production of wet season crops is caused by the Fitzroy River floods overflowing the river banks every two or three years inundating the crop area with up to 3 feet of water.

Following the acquisition of the adjacent Liveringa Station in 1963 by Northern Developments, plantings of up to 2,800 acres of dry season fodder sorghum were made for use as stock feed.

In 1969 the interests of Northern Developments Pty. Ltd. were acquired by the Australian Land and Cattle Company with whom the Government has an agreement covering the use and development of the Camballin Irrigation Area.

Australian Land & Cattle Company operates a number of cattle stations in the West Kimberley Area and it is planned to integrate the operation of these properties with the irrigation area for cattle fattening and production of sorghum.

A large feedlot is being operated by the Company near Camballin. During 1972, 3,570 acres of grain sorghum, 320 acres of corn and 420 acres of fodder were grown and the Company is expanding its crop area.

In collaboration with the Government, the Company has been investigating the construction of a levee to protect the irrigation area from flooding by the river during wet seasons and means of assuring more adequate irrigation supplies during the "dry" season.

The Company has established connections for the export of sorghum to overseas buyers.

PRIVATE IRRIGATION

Water is obtained from uncontrolled streams and underground sources to irrigate 11,152 acres in the Perth Division, and 16,614 acres in the South-West Division on orchards, market gardens and for fodder crops and pastures. 600 acres are irrigated in the Kimberleys, mainly for fodders and 4,378 acres elsewhere in the State.

DUNHAM IRRIGATION AREA

In the East Kimberley region Goddard of Australia, purchased Dunham River Station in 1967 and, under an agreement with the State Government, is developing a pilot irrigation scheme for integration of sorghum production and the fattening of cattle.

A dam has been constructed on Arthur Creek with a storage capacity of 54,000 acre feet and the development of a 10,800 acre irrigation area is in progress.

SOUTH-WESTERN DISTRICTS - IRRIGATION STATISTICAL SUMMARY

District	Area of District (acres)	Ultimate Rateable Area (acres)	Present Rated Area (acres) 1971/72	No. of Individual Assts. 1971/72		Source of Supply	Capacity of Reservoir (acre ft.)	Capital Expenditure Irrigation to 30/6/72 $
				Farm	Town-site			
HARVEY 1 in 1	5,322	4,057	3,660	284	137	Harvey Reservoir	7,100 (1)	5,388,629
HARVEY 1 in 3	32,615	10,893	10,123			Stirling Dam and Logue Brook Dam	46,191 (1) 19,717	
TOTALS:	37,937	14,950	13,783	284	137		73,008	5,388,629
WAROONA	10,330	3,503	3,483	84	45	Drakesbrook Reservoir & Samson Reservoir Waroona Dam	1,855 7,437 (1) 12,105	2,207,873
TOTALS:	10,330	3,503	3,483	84	45		21,397	$2,207,873
COLLIE	39,598	13,199	12,115	207	114	Wellington Reservoir	150,110 includes 55,000* for irrigation	6,264,235
GRAND TOTAL:	87,865	31,652	29,381	575	296		244,515	$13,860,737

(1) Reservoir capacity including flashboard storage.

* Safe draw for irrigation excluding other supplies.

All areas receive an average annual rainfall of 40 inches.

SECTION 3
THE WATER RESOURCES OF WESTERN AUSTRALIA

INTRODUCTION

Australia is the world's driest continent, and Western Australia, with an average annual rainfall of only 12.34 inches, is a very dry part of this continent.

Nevertheless, this amount of rain over such a large area, represents an enormous quantity of water. In fact, it is 640 million acre feet of water per year, or slightly over ten thousand times the capacity of Mundaring Weir.

(An acre foot of water is an acre of water one foot deep, and is 272,000 gallons).

However, most of this water evaporates or is used in transpiration from plants, and only about 6% of this rainfall becomes streamflow in rivers.

Despite these apparent drawbacks, the state still has vast water resources, which can be dealt with mainly under the following four headings :

1. Surface Water - water in rivers and streams.
2. Underground Water - water from bores and wells.
3. Re-use of Water - water, which has been used once, but which can be used again.
4. Desalted Water.

SURFACE WATER

Light rain soaks directly into the ground, but heavy rain, especially after earlier rains, causes surface runoff. This collects in drainage lines, then creeks and streams, and finally these join to form rivers.

Water can be stored very early in its journey across the land, such as in farmers' dams, and this is a very good method of exploiting surface water, because it catches the water where it is required.

In this State, there are many thousands of farmers' dams, and since this is one of the cheapest means of providing a local water supply, it will probably remain one of the most common forms of water supply in rural areas.

SUPPLIES FROM RIVERS

Salinities

The salinities of rivers in the Northern part of the State are generally quite good, but in the Southern part, as a general rule, only rivers which have forested catchments in high rainfall areas, yield fresh water.

Specific reasons for this salinity problem have not been fully determined, but rainfall, vegetation, soil type, and geology, all appear to affect the salinity of surface runoff.

In low rainfall areas in the southern part of the State, runoff is usually salt, and clearing almost invariably creates a salinity problem, but this is not so acute if the catchment is sandy.

This means the runoff into rivers from the developed wheatbelt is quite salty, and if a forested catchment is cleared for farming, the runoff is likely to become brackish. For this reason, clearing of some catchments is being restricted.

Rivers of W.A.

Looking at rivers of our State, and moving round the map in a clockwise direction, it could be noted that the southern rivers from Esperance to Albany, are all small and salt, except for the tiny, but fresh, Waychinicup River, and consequently they are of little value.

However, west of Denmark, the position is quite different, because here are a series of fresh rivers, which yield large quantities of water. These are the Denmark, Kent, Shannon, Gardner, Warren and Donnelly Rivers.

If all the fresh rivers in this area were dammed, they could supply 680,000 acre feet of water per year. This is equivalent to almost forty times the annual yield of Mundaring Weir, which indicates the huge potential of the deep south-west.

But the clearing of forests must be watched, as this source could be lost, by the rivers becoming brackish. Already the Frankland River in this same area is brackish, because its headwaters are in developed wheatbelt, and others could follow, if clearing is not prevented. For this reason, clearing on both the Denmark and Kent River catchment areas is now being restricted.

Next there is the Blackwood, a big river, but as it has much of its catchment in developed wheatbelt, its water is salty.

Further north the next interesting group of rivers are the Preston and its tributaries, Joshua Creek, Crooked Brook and Ferguson River. Probably these will all be used eventually.

The Collie River is at present dammed at Wellington Dam, which supplies water for irrigation downstream, and for inland towns of the Great Southern Towns Water Supply Scheme and additional dams could be built on this river.

The Harvey river and its tributaries are already partly exploited by dams for irrigation and more are possible.

By itself, the Murray River could supply 170,000 acre feet of water per year, or over nine times what we can draw from Mundaring Weir, but unfortunately it would be brackish, again because its headwaters are in the developed wheatbelt. Some fresh water could be obtained by damming its lower forested tributaries or at some future date, its brackish water could be mixed with the very fresh waters from the more northerly rivers to give potable water.

North of the Murray are a series of good fresh rivers. The North and South Dandalup Rivers, Serpentine Rivers, Wungong Brook and the Canning River. Some are already dammed, but all require additional storages to fully exploit them.

Like the Murray, the Swan-Avon River is salt, but unlike the Murray it is not likely to be dammed, as the main standard gauge railways runs down the Avon Valley. However, tributaries can be dammed, and some would yield fresh water. This of course includes the Helena River where we have Mundaring Weir.

Because they are brackish, rivers from North of Perth to the Gascoyne are not suitable sources of supply. The Gascoyne River is not likely to be dammed because the few damsites on this river are so poor.

Even though it is an arid zone, the Ashburton and Pilbara areas contain a number of mighty rivers, and with the rapid development of the Pilbara, dams to supply steel industries etc., will probably be built on at least the Fortescue, Harding, Shaw and Coongan Rivers before the turn of this century.

Last of all, but certainly not least, comes the Kimberleys, which contains three quarters of all the water resources of Western Australia. Where big southern rivers discharge hundreds of thousands of acre feet per year, Kimberley Rivers discharge millions. Many of these great rivers can be dammed and with so much water available, the obvious use is irrigation, and irrigation on a grand scale.

This has started with the great Ord River Project. The Ord River dam has a capacity of 4.6 million acre feet, and can supply one million acre feet of water per year and irrigate 178,000 acres of land.

The Fitzroy River could provide almost as much water as the Ord, and could be the source of irrigation schemes.

UNDERGROUND WATER

Underground water, from wells and bores, is a very wide spread source of supply, and is being extensively used throughout the State.

Unfortunately much of our underground water is brackish, and potable is hard to find, but it would be the most common source of water in farming and pastoral areas.

At present 54 towns, from Esperance to Kununurra, use underground water for their water supplies and it has been estimated that there are well over 50,000 bores in use throughout the State.

One of the areas, which has a great potential for underground water, but which is yet really very little used, is the Perth Coastal Plain which lies between the Darling Ranges and the coast, from Busselton to Geraldton.

This area often supplies abundant shallow ground water, in addition to deeper sometimes artesian water. Around Perth, this shallow groundwater is used by market gardens, and by some thousands of Perth householders for their gardens, but the potential both north and south of Perth is many times the present use, and this could be developed for irrigation.

The deeper aquifers are already tapped at places like Busselton, Bunbury, Yunderup, Perth, Arrowsmith River and Geraldton for town and industrial supplies, but there are big areas in between where much more is available.

The Pilbara is another area where underground water is proving very important, and all of the important centres here are supplied with water from underground.

Of particular interest is the Millstream Scheme, supplying Dampier and Karratha and currently being extended to Wickham and Cape Lambert. Bores on Millstream Station are equipped with pumps yielding 1.2 million gallons per day per bore.

RE-USE OF WATER

When water is used it is normally considered to be dirtied and is thrown away; but this is a very wasteful system.

By correct treatment, polluted water can be made usable again, and become a valuable source.

Sewage effluent is an obvious source of such water, and Perth currently dumps 11.5 M.G. per day of potentially usable fresh water into the ocean from its treatment works. This quantity will increase annually, and consideration to its treatment and re-use will probably become necessary.

Country areas are leading in this field. At Katanning, Narrogin, Merredin, Kalgoorlie, Northam, Kojonup, Kambalda, Mt. Newman, Dampier and Port Hedland treated sewage effluent is being used for irrigation of playing fields, parks, etc. Similar plans are being considered for Karratha.

DESALTED WATER

The ocean contains a virtually unlimited quantity of water, which if desalted could become another fresh water resource. Similarly, our brackish and saline underground water, and rivers could provide usable water if it were desalted.

Already, there are a number of desalting plants in this State. e.g.

U.S. Navy Base - N.W. Cape - 50,000 and 8,000 gallons per day,

Lake McLeod - Two at 8,000 gallons per day,

plus a number of smaller plants.

At present, desalting is a very expensive process, but with time, technology will improve and reduce costs. Future supplies from desalting could be used in two fields in this State :

1. Small inland towns could be supplies with plants to desalt local brackish water, thus avoiding the need for long costly pipelines;

2. Large coastal towns, where there is not enough readily available fresh water, could use desalted sea water.

WATER PURITY

Water is treated to purify it and improve the quality. Treatment can correct contamination by bacteria, objectionable taste, odour, colour, turbidity, hardness and to remove iron.

Contamination is caused by decaying vegetable matter, animal and human excreta, dead animals or other organic matter.

It is not possible to judge from appearance, clearness and taste whether water is fit for human consumption. Water that is clear and sparkling might contain harmful bacteria and be unfit to drink. Water is a ready medium for the spread of certain types of disease. Ordinary organic pollution may cause diarrhoea but the greatest danger associated with drinking water is the possibility of its recent contamination by sewage or human excrement. If among the contributors there are carriers of such infectious diseases as typhoid and paratyphoid fevers or dysentery the water will almost certainly contain the living germs of these diseases.

Nature can do an excellent job of purification by means of oxygen, sunlight, worms, snails and other fish life etc.

However to ensure that water is safe to drink it can be treated with chlorine.

There are two general methods of chlorinating water :-

(a) by use of chlorine gas

(b) by using bleaching powder solution or sodium hyperchlorate solution.

The most effective method is to add chlorine in measured quantities from compressed chlorine gas through a chlorinator. These are usually located at the pumping station for the delivery of water from a dam or reservoir.

The other method used on small dams is to mix the bleaching powder into a milk like consistency and spread it over the water surface. As an alternative the powder may be sprinkled on the surface of the water to be treated. As the powder sinks the entire volume of the water is treated.

Tastes and odours are also caused by decaying organic matter. Normally for treated water supplies a small quantity of pulverised activated carbon is fed with filter alum to absorb the gases.

Colour is generally derived from the solution of matter from dried leaves, peat and other vegetable substances. Sometimes it is due to iron or manganese combined with organic matter. Colour is mostly in solution and occurs in soft water usually from streams arising in bogs and swamps and where the rocks are devoid of limestone, sandstone and shales etc.

Turbidity is the suspension of large quantities of matter in the water. It is generally inorganic clays and silts washed by rain from adjacent soils.

Colour and turbidity are treated by a flocculation process that requires the addition of a coagulant to the water. The most common used being aluminium sulphate.

Hardness in water is due to the presence of bicarbonates, sulphates, chlorides and nitrates of magnesia or lime. Hardness that is due to bicarbonates of lime or magnesia is known as temporary hardness and can be removed by boiling the water in an open vessel for a sufficient length of time. This drives off the carbonic acid and leaves the solid residue that sinks to the bottom of the vessel.

Permanent hardness is due to solutions of sulphates, chlorides or nitrates of lime or magnesia and can only be removed by chemical treatment.

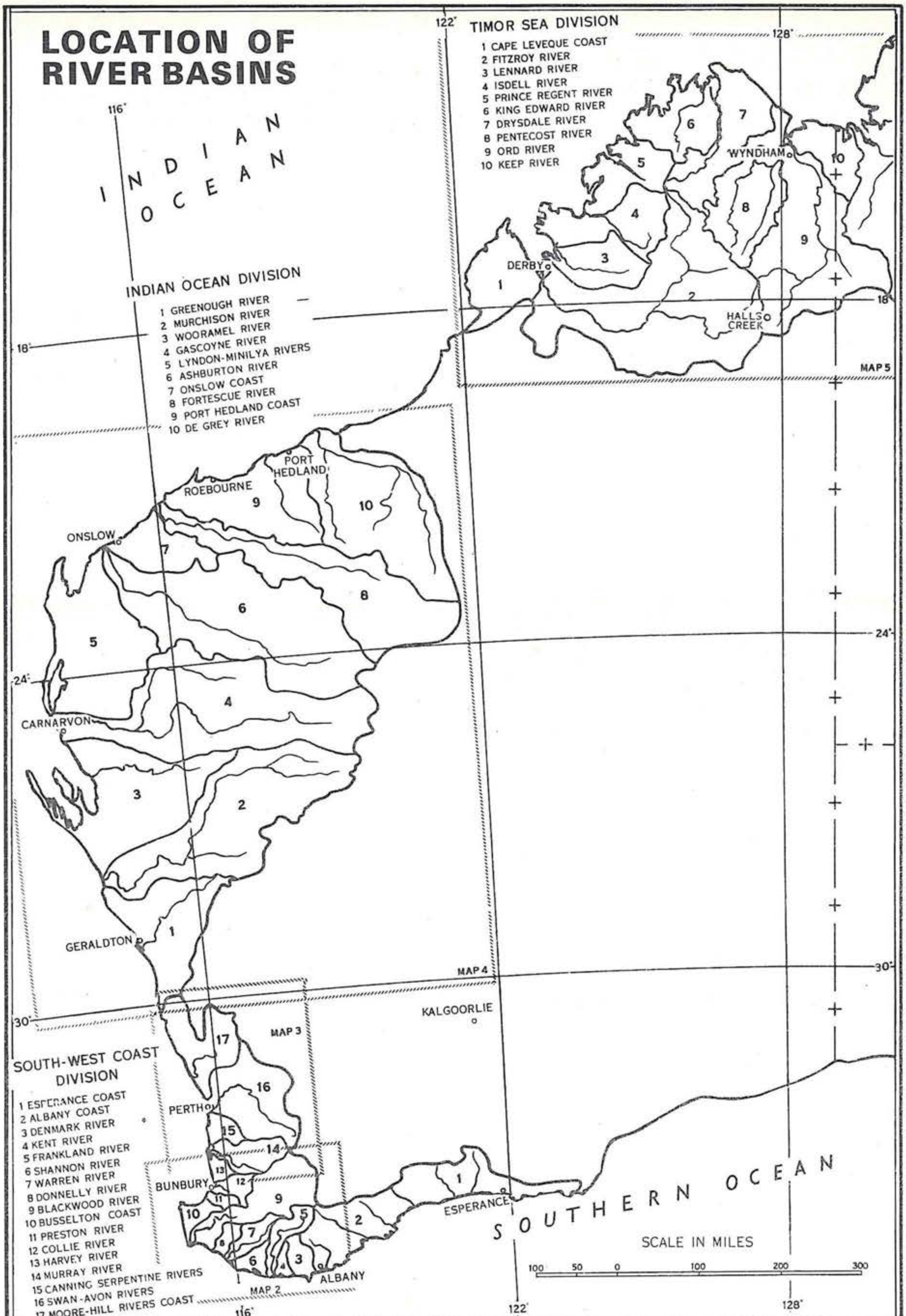
The primary problem caused by hardness is economic - increased cost of soap consumption and scales formed in boilers and hot water systems.

In practice the most common methods of water softening are the lime soda process or the ion exchange process.

Waters containing iron are usually derived from underground sources. Sands, gravels and rocks always contain iron as ferric oxide. The water that percolates through the soil often has carbonic acid and organic matter in solution which transforms the ferric oxide into carbonate of iron. This dissolves and is carried by water. The action does not take place in waters containing free oxygen. Water containing iron either as carbonate or as a sulphate in amounts greater than .5 parts per million is unfit for most domestic and industrial purposes, and has a disagreeable taste.

In the reticulation where the velocity is slow the iron is deposited in pipes and assists in the growth of an organism called Crenoathrise. Living Crenoathrise cause no trouble but as soon as they die the decayed remains give to the water a disagreeable taste and odour.

The removal or iron is by oxidation on exposure to the air. The iron is changed from a ferrous to a ferric state and precipitated as ferric hydrate (rust). Usually oxidation is carried out by coke tray aerators where the water is passed over several trays of coke or by spray aeration. In practice the ferric suspension is often so fine and the settling velocity so slow that a flocculation process (similar to that used for the removal of colour and turbidity) requiring the addition of a coagulant such as aluminium sulphate is necessary.



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