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WATER RESOURCES OF CENTRAL AUSTRALIA

by

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INTRODUCTION

The area within the Northern Territory south of the latitude 20° south is here referred to as Central Australia. It is an arid area, without permanent rivers, and the mean annual rainfall varies between 5 inches in the south and 12 inches in the north where there is a pronounced summer seasonal maximum. The rainfall is very unreliable. There is insufficient natural surface water for the needs of the pastoral industry. Small surface storages and bores are used to water cattle grazing on natural pastures. The natural rainfall must be supplemented by irrigation for a stable agricultural industry, which will therefore be restricted to small areas in Central Australia.

The work of the Resident Geologists and others toward determining the water resources of Central Australia is reviewed. It must be stressed that the assessment of the water resources of any area can only be done through the work of a co-ordinated team of geologists, engineers, geophysicists, chemists, agronomists, and economists.

PREVIOUS INVESTIGATIONS

Since 1951 geologists of the Bureau of Mineral Resources, attached to the Mines Branch of the Northern Territory Administration, at Alice Springs have been engaged in the selection of sites for bores in the area and in the compilation of bore data.

Detailed studies of particular problems have been made by several organizations. Geological investigations into the Alice Springs Town Water Supply have been made by Owen (1952 and 1954), Jones (1957), and Quinlan and Woolley (1960). Seismic and resistivity surveys were made by Wiebenga and Dyson (1957). The results and conclusions from the 1956 to 1957 programme of test drilling, pumping tests and stream gauging are given by the Department of Works (1958) and the results of the 1959 to 1961 programme are being compiled by the Resident Geologists. The Water Resources Branch are continuing to stream gauge the Todd River. Jephcott (1959) correlated the changes in salinity of the water in the Town Basin with floods in the Todd River.

The groundwater problem at Yuendumu Native Settlement, 180 miles north west of Alice Springs, has been investigated by Quinlan (1958), Jones and Quinlan (1958), and the results of a resistivity survey are given by Wiebenga et al (1959).

The chemical content of groundwater within the Northern Territory and its suitability for pastoral and agricultural purposes was discussed by Jephcott (1957). Chemists of the Animal Industry Branch are continuing to analyse samples of groundwater.

Information from these various sources has been used to compile an outline of the water resources of the area (Jones and Quinlan 1959), and to indicate areas which warrant investigation of the availability of groundwater for irrigation (Perry et al M S).

WATER RESOURCES

The surface and underground water resources of Central Australia may be considered in terms of runoff, storage, quality and availability.

RUNOFF

If water is regarded as a renewable natural resource then, the water resources of Central Australia are limited by the quantity of runoff from suitable catchments each year. This water may be available for either surface or groundwater storage.

Runoff in Central Australia is believed to be adequate for the present development.

The replenishment of surface storages which may be constructed is dependant on the runoff available which is partly dependant on the character of the catchment. Three main types of catchments are recognized:

(a) those of strong to moderate relief within outcrop areas of rocks of Precambrian and Palaeozoic age. Runoff from this type of terrain is good and surface storages are more likely to be used for agricultural than for pastoral development.

(b) those of low relief, partially covered by soil and with outcrops of Tertiary laterite, and Mesozoic and Cainozoic rocks. Many catchments of this type are suitable for the construction of surface storages for pastoral use.

(c) those of low relief within areas of Quaternary aeolian sand and salt lakes. All of the water which falls of these areas is lost by evaporation and transpiration.

Groundwater Recharge

"The recharge of groundwater in the area comes entirely from the rain falling on the area or the adjacent ranges. Penetration of water to the water table is, in general, dependant on concentration of water by runoff. The most effective recharge conditions are those, such as at Alice Springs, where runoff from a hilly catchment area is channelled over a permeable bed with ready access to the water table. Recharge is very irregular, as it is dependant on the amount and intensity of rainfall and on the frequency of exceptionally wet periods" (Jones and Quinlan 1959).

STORAGE

If mining of groundwater can be justified on economic grounds then the limit to agricultural and pastoral development is set by the quantity of water held in surface and groundwater storage. The latter is very much greater than the annual runoff in the area.

(a) Surface Storage

Surface storages with capacities up to 4½ million gallons have been constructed for pastoral use. A considerable quantity of water is lost each year by evaporation and in some cases by seepage. Sealing of the water surface and the floor of the storage will reduce this loss.

(b) Groundwater Storage

Water is added to underground storage by infiltration following concentration of runoff, and is lost from storage "both by sub-surface flow and by evaporation and transpiration".

"Groundwater loss by evaporation is largely confined to the salt lakes and adjoining areas. Water table and salinity information show that the near-surface moisture in these lakes is supplied entirely from the groundwater except for short periods after rain. Loss by transpiration is more widespread, but is also confined to areas of relatively shallow water table. No estimate of the relative importance of evaporation and transpiration is possible, but together they account for the greater part of the groundwater loss from the western half of the area".

"In the eastern half of the area, the main loss is by sub-surface flow towards the Barkly Tableland and the Great Artesian Basin" (Jones and Quinlan 1959).

QUALITY

The quality and nature of dissolved solids in water is a factor which governs the usefulness of the resources available. The minimum acceptable standard of water quality depends on the use to which it will be put.

(a) Surface Water

The salinity of surface waters is generally low, but they are commonly muddy. If siltation of the surface storages is to be avoided the quantity of suspended solids in runoff water should be as low as possible. One sample from flow in the Todd River had a silt content of 6% by volume.

(b) Groundwater

The content of dissolved solids in groundwater is complex and variable. Some of the contributing factors are the presence of salt in the rocks, the availability of recharge and the velocity of groundwater flow.

Recommendations on quality limits for groundwater have been made by chemists of the Animal Industry Branch (Jephcott 1957), these are:

(i)	Sheep	12,000 to 15,000	ppm
(ii)	Station cattle	10,000	ppm
(iii)	Working horses	6,000	ppm
(iv)	Domestic consumption	3,000	ppm

These limits are modified if particular ions are present in excess of certain concentrations. For example the maximum limits for individual ions are (Jephcott 1957):

	Small Towns	Homesteads
	ppm	ppm
Fluorine	1	1
Magnesium	200	200
Sulphate	375	500
Chloride	375	750

"The so-called "blue-baby" disease appears to be a possible hazard with waters containing more than 10 parts per million of nitrate expressed in terms of nitrogen (N). .... The tentative limit when concentrations are expressed as NO_3 is, in round figures, 44 ppm". (Hem 1959).

AVAILABILITY

Because of the geological structure and the physiography of the area, aquifers and or catchments suitable for surface storage are not readily available throughout the area.

The suitability of various catchments for surface storage is being investigated by engineers of the Water Resources Branch.

The availability of groundwater depends on the distribution of the three main types of aquifers (Jones and Quinlan 1959). The three types closely correspond to the following groups of broad lithological units (Quinlan 1959):

(i) Metamorphic and igneous rocks of Precambrian age,

(ii) Sedimentary rocks of lower Proterozoic to Upper Palaeozoic age,

(iii) Sediments of Permian to Recent age.

The distribution of these units within the zone of saturation, and the availability of aquifers is discussed in terms of the Groundwater Provinces by Jones and Quinlan (1959).

(i) Metamorphic and igneous rocks of Precambrian age.

Aquifers in this group are weathered and fractured zones. They are of limited areal extent and are commonly difficult to find. In general the specific capacities of bores withdrawing water from them are small, either because of low permeability or poor interconnection between fracture zones. While aquifers of this group may provide sufficient water of moderate quality for pastoral and homestead purposes it is very unlikely that irrigation supplies could be obtained.

(ii) Sedimentary rocks of lower Proterozoic to Upper Palaeozoic age.

Some sandstones and limestones of this group are useful aquifers, and will provide large quantities of groundwater. "The necessary drilling depth (or the depth at which water will be struck) may be predicted from the geological structure. However in some areas, (e.g. the Missionary Plain) the required depth may be too great to be economic" (Jones and Quinlan 1959).

(iii) Sediments of Permian to Recent Age.

The aquifers of this group are flatlying and with the exception of the Tertiary and Quaternary limestones, they are generally unconsolidated and non-homogeneous. They may be thin and of limited areal extent, but there is commonly a high degree of interconnection between individual aquifers.

In the south-east part of the area these sediments form part of the Great Artesian Basin. Here, because the aquifers are overlain by a regional aquiclude, confined groundwater is readily available over wide areas.

Elsewhere marine and terrestrial sediments occur as infilling of erosional basins adjacent to ranges of crystalline rocks. Fourteen relatively large basins are known (Perry et. al. M.S. and Table 1). While the storage coefficient of the sediments as a whole is not expected to be greater than 0.05, the volume of saturated sediment is sufficiently large for groundwater storage to be adequate to maintain yields during periods of low recharge. Because the deposits are non-homogeneous, difficulties can be expected in the location and development of bores with very large yields.

RESOURCES FOR PASTORAL DEVELOPMENT

The resources available, in terms of both storage and runoff, are considered to be more than adequqte for the pastoral industry. There is, as yet, no sign of regional depletion. Many cases of bore failure or reduced yield are due to secular fluctuations in water level which may be as much as 50 feet, e.g. Willowra Homestead Well.

However groundwater may not be available in suitable quantity and quality in the immediate area where an additional watering point is required. In these cases use has been made of catchments which are suitable for surface storage.

A qualitative assessment of the groundwater resources available has been made in terms of Groundwater Provinces by Jones and Quinlan (1959). Insufficient basic data on water levels, permeability and recharge have yet been obtained to permit a quantitative assessment.

There are approximately 1,000 pastoral watering points in the area. Assuming that the effective radius of feeding is 5 miles the area which can be grazed from the existing surface waters and bores, allowing for overlap, is about 53,000 square miles (Perry, unpublished data). It is estimated that 10,000 acre feet per annum of water is used by the pastoral industry.

RESOURCES FOR IRRIGATION

To date surface storages have not been used to provide water for agriculture. However, it is likely that suitable catchments, with strong to moderate relief, are available in the MacDonnell, Reynolds and Davenport Ranges.

There are seventeen areas (Table 1) in which it is suspected that quantities of groundwater, suitable for irrigation, are available (Perry et al M.S.); these warrant investigation.

The following arbitary criteria were used in the selection of the areas.

(i) Quality, less than 1500 parts per million of dissolved solids. The sodium absorption ratio of the low salinity waters is generally satisfactory.

(ii) Lift, less than 100 feet and preferably less than 50 feet. The precise limit will be determined by the economy of the industry.

(iii) Yield to be expected from bores, sufficient to permit the economic use of turbine pumps.

(iv) Recharge, to be in excess of 1,000 acre feet per annum in each area.

(v) Storage, many times larger than recharge.

In two of the areas the aquifers available are sandstones of Palaeozoic age, which have been deformed into larger folds. In the McDills area sub-artesian water is available from Mesozoic aquifers in the Great Artesian Basin. In the fourteen other areas groundwater is stored in sediments of Mesozoic and Cainozoic age which fill erosional basins in Precambrian rocks. Water can be withdrawn, with low lifts, from bores in or near outcrops of Quaternary Kunkar.

Samples of water from one of the areas (Woolla-Harpers) were analysed by chemists of the Animal Industry Branch and contained 50 to 180 parts per million of nitrate. This is of interest as the quantity of artificial fertilizers required for crops would be reduced if water with this nitrate content were applied. However if the nitrate is derived from pollution and surface infiltration the high nitrate level may not be sustained with prolonged pumping.

RESOURCES FOR TOWN SUPPLIES

Many of the towns and settlements in the area are underlain by Precambrian igneous and metamorphic rocks, and in places adequate supplies of good quality groundwater are not available, e.g. Kulgera, Yuendumu, Aileron, and Barrow Creek. Several settlements, notably Papunya, Amoonguna and Warrabri, have as a result of geological advice, been built on sediments of Mesozoic and Cainozoic age which can be expected to yield adequate supplies of groundwater.

Water for the Alice Springs Town Supply is withdrawn from a shallow alluvial basin beneath the town. Previous estimates of the quantity of potable water stored in the basin range from 330 million gallons (Jones 1957) to 1,110 million gallons (Dept. of Works 1958). The latest estimates, based on the present programme of test drilling and pumping tests, indicate that the available storage is between 300 and 500 million gallons.

CONCLUSION

This preliminary assessment of the water resources shows that water is available for further development of the pastoral industry and suggests that quantitative studies in selected areas could prove resources adequate for the establishment of an agricultural industry.

The problem of which to develop first - surface or groundwater storage - mainly involves economics and the availability of storages of both types. However it would seem reasonable to assume that readily available groundwater resources should be utilized before those surface water resources requiring large capital expenditure.

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TABLE I

CHARACTERISTICS OF SEVENTEEN CATCHMENTS AND BASINS IN CENTRAL AUSTRALIA

Catchment or Basin	Area of catchment with strong to moderate relief (square miles)	Mean Annual Rainfall (ins)	Annual Recharge *	Groundwater Storage +	Depth to water at withdrawal point ‡	Quality 0	Remarks
1. Narwietooma	790	10	large	large	shallow to moderate	good to moderate	
2. Hamilton	660	10	large	large	shallow to moderate	good to moderate	
3. Woolla-Harpers	150	11	moderate	large	shallow to moderate	good to moderate	possibly
4. Ti Tree	350	11	moderate	large	shallow to moderate	good to moderate	interconnected
5. Ingallana	70	11	moderate	?large	shallow to moderate	good to poor	
6. Lander River	950	11	?large	large	moderate	good	infiltration may be poor
7. S.W. Davenport Range	1040	12	large	large	moderate to shallow	variable	in several small basins.
8. Mt. Leibig	310	10	moderate	large	shallow to moderate	mainly moderate some good	
9. West of Willowra	?	12	unknown	large	?shallow	?saline	
10. Bogga Bogga	not estimated	8	moderate	?large	moderate	unknown	
11. Britten Jones	not estimated	8	moderate	?large	moderate	unknown	
12. Utopia	900	10	large	?small	shallow and moderate	good	areal extent of aquifer unknown
13. Red Tank	590	10	large	large	shallow	?good	withdrawl point indefinite
14. Hale River	1640	10	large	unknown	shallow	good	
15. Tempe Downs	30	8	moderate	moderate	moderate	unknown	sandstone aquifers
16. Lalgra	?	8	moderate	moderate	shallow	?good	broadly folded
17. McDills	?	-	?large	large	shallow to moderate	moderate	portion of Great Artesian Basin, main aquifers confined.

* large	$>10^4$ acre feet	+ large	$>10^5$ acre feet	‡ shallow	$<$ 50 feet	0 good	$<$ 1500 ppm T.D.S.
moderate	10^3–10^4 acre feet	moderate	10^4–10^5 acre feet	moderate	50–100 feet	moderate	1500–3000 ppm T.D.S.
small	$<10^3$ acre feet	small	$<10^4$ acre feet	deep	$>$ 100 feet	poor	$>$ 3000 ppm T.D.S.