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GROUNDWATER IN THE AUSTRALIAN ARID ZONE

by

N. Jones

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Groundwater is taken to include all water in the zone of saturation, both free and confined.

The rocks which form the aquifers of the arid zone are almost invariably much older than the present arid cycle; differences in groundwater conditions between the humid and arid zones are largely due to differences in the location and amount of recharge and discharge.

Less than one-third of the Australian arid zone receives significant additions of water, either surface or underground, from the humid zone, and mountains with sufficient relief to provide humid islands are lacking. On the other hand none of Australia has an extreme arid climate.

Recharge does not occur through all permeable beds, but only where more water is available than can be retained by the outcropping beds. Under arid conditions water must be concentrated by run-off for recharge unless the intake retains little moisture e.g. outcropping jointed quartzite. Most arid zone streams are influent throughout their length and recharge may be expected wherever they cross permeable beds.

The major intake area of the Great Artesian and Murray Basins have been clearly delineated by maps of the piezometric surface. For most of the large, and some of the small basins intake areas can be indicated but quantitative data on actual or potential recharge are not available either for basins as a whole or for smaller areas.

Induced or artificial recharge may enable withdrawal from an aquifer to greatly exceed natural recharge before development. But in the arid zone, where there is little or no flow of surplus water from the area, increased recharge at one point may mean reduced recharge at another.

Natural discharge of groundwater occurs by:

(1) Subsurface flow from the arid zone - generally to the ocean, e.g. the Carnarvon and Eucla basins.

(2) Seepage to effluent rivers - the Gregory River is an example; but effluent streams are not important for most of the Australian Arid zone.

(3) Evaporation from mound springs and salt lakes; this is probably the main manner of discharge, e.g. mound springs of Great Artesian Basin and salt lakes of Central and Western Australia. Adjacent to evaporation areas groundwater may be discharged by transpiration. Some of the salt lakes receive large quantities of surface water from periodic floods, but others, e.g. Lake Amadeus, lack a tributary surface drainage system. In other arid zones, such as the Sahara, recognition of salt lakes and marshes as major points of groundwater discharge has been followed by the discovery of valuable groundwater resources. Major discharge of groundwater implies an aquifer to carry this water from a recharge zone even though at present, we cannot name the geological formation constituting the aquifer or clearly establish its intake.

The value of groundwater depends not only on quantity but also on quality, which includes chemical, physical and biological aspects. Any, or all, of these aspects may be important but salinity is the most common quality problem in the arid zone.

In coastal areas cyclic salt is a major source of salt but inland salt must be derived mainly from the topsoil over which the recharge waters flow or from the rocks through which the groundwater moves. Salt is concentrated where recharge water or groundwater is subject to evaporation, and also by continued dissolution of salts from the aquifer. Aquifers with large storage and small recharge and consequent slow groundwater movement may contain saline water through most of their extent e.g. Eucla Basin.

Although groundwater flow is adjusted to the present climatic cycle the salinity pattern, particularly in the large basins, may be largely a relic of recharge-discharge conditions of an earlier climatic cycle.

Salinity, like recharge, may be modified by artificial discharge - it will generally decrease with induced recharge, but will increase if the hydraulic gradient to saline water is reversed.

Occurrence of groundwater in the Australian arid zone

Most summaries of Australia's groundwater resources have drawn a clear, perhaps too clear, distinction between free and confined waters. The differences are important but free and confined waters commonly occur in the same basins and share the same zones of recharge and discharge.

Four broad groups of aquifers may be distinguished in the Australian arid zone:

(1) Metamorphic and igneous rocks, largely Precambrian, form much of the western half of the arid zone and also occur in two smaller areas surrounding the mining centres of Broken Hill and Mount Isa. Groundwater is generally of small quantity and variable quality. Most aquifers are small, disconnected, and difficult to locate; they include fracture zones and porous zones formed by weathering and where the zone of weathering does not extend below the water table virtually no useful aquifers may be present. Many small stock and domestic supplies have been developed but bores yielding more than 1000 g.p.h. are not common and resources are rarely adequate for town supply or irrigation. The Cabbage Gum Basin, south of Tennant Creek, where the main aquifer is decomposed granite, is now being tested and may prove to be one of the valuable exceptions.

(2) Folded sedimentary rocks include the Upper Proterozoic sediments of Western Australia, and sediments in the Amadeus Trough, Officer Basin, Flinders Ranges, and much of the Ord-Victoria region. Aquifers include some sandstones with intergranular porosity and permeability, but most rocks are indurated, and fractures in sandstone and limestone and solution cavities in limestone form the main aquifers. Shales and many of the shaly limestones and sandstones do not form useful aquifers. Individual bores in the better aquifers have capacities of several thousand gallons per hour, and compared with metamorphic rocks aquifers may be extensive and thick. The basins are divided by geological structures into numerous sub-basins each with distinct recharge and discharge. The distribution of fresh and poor quality water is generally complex. None of these areas has been systematically studied and the Officer Basin is virtually untested.

(3) The large, simple sedimentary basins include most of the Great Artesian Basin, the Canning, Carnarvon, Eucla, and Georgina basins, and part of the Murray Basin. The main aquifers range from Permian to Tertiary in age, except in the Georgina Basin where the main aquifer is of Cambrian age. Groundwater is present throughout the greater part of the basins, although in places the required depth of drilling may be too great except for special purposes e.g. the critical stock watering points along the Birdsville track. The aquifers are porous gravels, sands, sandstone, and limestone, although in the Georgina Basin fractures and solution cavities are important. With thick aquifers and large pressure heads yields of tens of thousands of gallons per hour are common, and there are large areas of artesian flow in the Great Artesian, Canning, and Carnarvon basins. Groundwater storage in these basins is extremely large but intake areas are commonly restricted and intensive development away from them may cause serious decline in head.

It has commonly been assumed that hydrological patterns in these basins are simple. Recent geological work suggests that the aquifers are variable, discontinuous, and overlapping. A more complex hydrological pattern may be found as detailed study of the basins continues.

The Great Artesian Basin is the best known of the large basins, from extensive investigations of the problem of decline in head. The Queensland portion of the basin has yielded, since 1890, more than 20 million ac. ft. by depletion of elastic storage (i.e. in excess of recharge). In 1954 flow was approximately 230 million g.p.d. and depletion was still occurring but it was believed that in some 60 years recharge and total discharge would be balanced at approximately 130 million g.p.d. After allowing for bore drain losses adequate water would be available for stock and domestic requirements but little could be made available for irrigation even where the water was of suitable quality.

The groundwater in the large basins is generally of suitable quality for stock but much is not suitable for town supply and little is suitable for irrigation. In the Eucla basin however much of the water is saline and the rest of poor stock quality.

The most favoured areas of the large basins are outside the arid zone (southern part of Murray Basin) or just within it (eastern part of Great Artesian Basin, northern part of Canning basin).

(4) Small basins with Mesozoic and Cainozoic sediments, and alluvium-filled valleys, have generally been underestimated in assessing the arid zone's groundwater resources; partly because they have been, and in many cases still are, little known and partly because their higher recharge opportunity was not appreciated. The majority of these basins are too small to show on a small-scale map of the arid zone. The thickness of the basin sediments ranges perhaps up to 1000 feet, and the basins are superimposed on each of the other aquifer groups. The aquifers are gravel, sand, and limestone, which may occur in lenses but, where studied the lenses are sufficiently inter-connected for the basins to function as hydrologic units. The sedimentary basins commonly underlie topographic depressions and receive recharge from run-off waters from adjoining areas underlain by rocks of other aquifer groups. Recharge may be prevented by an extensive aquiclude, as in the Willochra basin.

The alluvium which overlies older aquifers along river valleys may be included with this group, for groundwater in the alluvium is commonly separated from underlying aquifers by extensive aquicludes.

Several basins are known near and north of Alice Springs; they contain up to 600 feet of Mesozoic and Cainozoic sediments. Tentative estimates of available recharge are of the order of 5×10^4 ac. ft./year with a storage of better quality water approximately 50 times average annual recharge. Similar basins occur in the Wiluna area of Western Australia, and provide the only sizeable groundwater prospects at present known in that part of the shield.

Most bores yield at least 1,000 g.p.h. and bores yielding more than 10,000 g.p.h. are known in some of these basins, but considerable prospecting is necessary to locate the better aquifers. Salinity commonly ranges between wide limits and good and poor quality waters may be in close proximity, but where recharge is good some better quality waters normally occur.

Use of Groundwater

The present use of groundwater in the arid zone may be summarized:

(1) Groundwater is the source of permanent stock waters for the greater part of the pastoral country.

(2) Domestic supplies for homesteads, small mines, etc., have been obtained in many areas, although not all supplies used are of satisfactory quality.

(3) Many town supplies are from groundwater, e.g. Cloncurry, Longreach, Broome and Wiluna. In some extensive areas large local water sources, surface or underground, are not available and water must be imported, e.g. Woomera and parts of the West Australian gold belt.

(4) Irrigation on a small scale is practised near some towns, e.g. Carnarvon and Alice Springs.

Future prospects are that:

(1) Groundwater can provide the bulk of stock waters in new pastoral areas, and additional closer-spaced watering points in areas currently occupied. In most areas adequate yields can be obtained, but in some areas all adequate supplies may be saline. It is assumed that a low success rate in drilling and some variation in spacing of watering points are acceptable.

(2) A wider spread of domestic supplies is possible but in many areas groundwater for this purpose would require desalting.

(3) Additional, and larger, town supplies can be obtained in many areas within reasonable distance of likely points of consumption. Town supplies have generally similar requirements to irrigation water, except that pump depths may be greater.

(4) Groundwater supplies suitable and adequate for irrigation are available in favourable areas. Without doubt further areas are yet to be discovered. The restrictive factors are recharge and salinity rather than storage and yield, which are commonly adequate except in the metamorphic and igneous aquifers. Irrigation areas would have to be small and scattered, as are the areas of more favourable recharge even where the storage is extensive.

This assessment of future prospects is based partly on information from current development and partly on geological and hydrological comparison with other basins believed to be similar to those in the Australian arid zone. Recommendation for intensive development of any particular basin must be based on a quantitative appraisal of the resources of that basin - determination of the shape and volume of the reservoir, measurement of the aquifer's coefficient of storage and transmissability, and calculation of recharge and discharge - leading to an assessment of the effects of proposed development on the piezometric surface, salinity, and recharge of the groundwater.

Groundwater prospects in the arid zone certainly appear more encouraging than they did ten years ago, but irrigation with groundwater can provide a basis for closer settlement for less than one per cent of the arid zone.