EXPLANATORY NOTES TO ACCOMPANY
THE GROUNDWATER MAPS OF THE
NORTHERN TERRITORY

by

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II. CliMAtE

The Northern Territory lies between longitudes 129°E and 138°E and extends southward to latitude 26°S. Latitude 20°S divides the territory into the area commonly known as the "Top End" and the "Centre". The total area of the Northern Territory is 1,356,200 km².

Climatic differences between northern and southern parts of the territory are extreme. The median annual rainfall decreases fairly uniformly southward from 1,546 mm at Darwin to 256 mm at Alice Springs (Bureau of Meteorology, 1963). Rainfall reliability also decreases southward. Conversely, the mean annual evaporation increases southward from 2,100 mm at Darwin to a maximum of about 2,921 mm in the vicinity of Marrakinn Creek; a slight decrease to about 2,540 mm at Alice Springs then occurs before values resume their increase southward to 3,048 mm at Lake Eyre. The quantity of water available annually for recharge of groundwater reserves thus decreases southward; a corresponding decrease in rates of groundwater flow may explain the general southerly increase in total dissolved solids in groundwater.

A concentration of rainfall into the summer months in most of the territory is evident from the monthly rainfall figures in the table below.
<table>
<thead>
<tr>
<th>Month</th>
<th>Darwin</th>
<th>Alice Springs</th>
<th>Darwin</th>
<th>Alice Springs</th>
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<tr>
<td>JUN</td>
<td>157</td>
<td>330</td>
<td>304</td>
<td>15</td>
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<tr>
<td>JUL</td>
<td>145</td>
<td>305</td>
<td>317</td>
<td>14</td>
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<tr>
<td>AUG</td>
<td>152</td>
<td>254</td>
<td>251</td>
<td>11</td>
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<td>152</td>
<td>229</td>
<td>73</td>
<td>5</td>
</tr>
<tr>
<td>OCT</td>
<td>176</td>
<td>127</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>NOV</td>
<td>178</td>
<td>102</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DEC</td>
<td>203</td>
<td>127</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>JAN</td>
<td>216</td>
<td>205</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>FEB</td>
<td>241</td>
<td>254</td>
<td>45</td>
<td>15</td>
</tr>
<tr>
<td>MAR</td>
<td>216</td>
<td>279</td>
<td>118</td>
<td>18</td>
</tr>
<tr>
<td>APR</td>
<td>178</td>
<td>305</td>
<td>215</td>
<td>17</td>
</tr>
</tbody>
</table>

The lack of rainfall and high evaporation during the winter months results generally in surface waters falling with the result that heavy reliance is placed on groundwater during these months.

Legislation important to groundwater development in the Territory is the Water Supplies Development Ordinance 1960-1965. This ordinance provides finance for the development of surface and/or groundwater supplies for pastoral or agricultural purposes. The finance is in the form of a loan or, for 'dug' bores drilled under approved conditions, a re-imbursement of drilling expenses. To qualify for assistance, bores must be cited by a geologist, must not be drilled beyond a certain depth without the ascent of the Commissioner of Water Development, must be fully cased, and must yield water of a minimum quality and
quantity. Strata and water samples together with all drilling details must also be forwarded to the Commissioner on completion of the bore.

Most water bores in the Territory either serve the pastoral industry or provide supplies for the various centres of population, particularly along the Stuart Highway. Others supply aboriginal settlements, mine treatment plants and townships, tourist centres and agricultural and horticultural areas. In addition, a number of bores which are not withdrawn water now have provided useful groundwater information: Army and Air Force bores drilled along the Stuart Highway during World War II, bores drilled to supply water for road construction, stratigraphic and scout bores drilled to aid geological mapping, petroleum exploration wells and groundwater investigation bores are examples.

Groundwater information on the four maps is not wholly scanty to non-existent in the five large areas of the Territory which are not covered by pastoral leases - the large aboriginal reserves of Arnhem Land and the south-west corner, the Kin冈on leases and the two arid desert areas extending from Tennant Creek south-east to the Queensland border, and west to the Western Australia border. Kendall (1967, 1969) quotes figures for the average area served by working bores on selected pastoral leases in the Barkly Tableland and the eastern Victoria River District. The highest density is 1 bore per 100 km² on Brunette Downs; the average density for leases on the Barkly Tableland and for Wau Hill Station is about 1 bore per 200 km². In good grazing areas on Wau Hill Station, bores are being developed no more than 8 km from each other, each bore serving 50 km². On flat country with an annual rainfall greater than 700 mm, improved pasture may be developed (Cocks, pers. comm.). The resultant increased carrying capacity of the land and the smaller areas fenced tend to increase the density of pastoral bores.
.. at Marbulloo Station, south-west of Katherine, a central bore serves each fenced area of 40 km² of improved pasture. The 700 mm isohyet (median value) crosses the territory approximately east-west near Larrimah (Bureau of Meteorology, op. cit.), improved pasture development of flat lands to the north, e.g., the Daly River basin, seems likely.

With the exception of Muluana, the major centres of population are restricted to the Stuart Highway. Darwin is the only centre which in 1972 does not rely on bore for water supply. However between the years 1971 and 1972, until a second surface water storage was completed, the Darwin water supply was supplemented during the dry season by groundwater from bores in the Palmer's Lagoon area. Even Katherine on the banks of the perennial Katherine River relies entirely on groundwater to avoid the problem of seasonal high turbidity and the need for chlorination in a river water supply.

Water supply for aboriginal settlements has generally required groundwater investigations and drilling in remote areas. Examples are the settlements on the north coast and adjacent islands which are reached by air or by sea only and Docker River settlement in the South-west corner of the Territory. Pumps have been installed at some of the coastal settlements where fresh water exists close to the surface in marine deposits, e.g., at Port Bay Settlement.

The mining industry relies heavily on groundwater for treatment plants and townships, the latter requiring better quality water than the former. Davies and Hide (1970), after successful investigations for groundwater to supply the treatment plant of Barrego Mine, north-west of Tennant Creek, state that:
"...underground water supply problems and the establishment of water reserves must be approached on just as systematic and scientific basis as in the case with the exploration and establishment of the actual ore reserves. The requirement for discovery of an adequate supply in such an arid area of Australia is no less important than the discovery of the actual orebody itself."

On Cove Peninsula both the town of Nhulunbuy and the bauxite ore treatment plant rely on ground water.

The development of tourist facilities at remote places in the centre e.g. Ayers Rock is increasing and bores are required for them.

To date, there is little agriculture in the Territory and groundwater requirements for irrigation are small. Undoolya Station, east of Alice Springs, irrigates lucerne with groundwater from the Musgrave sandstone. Tipperary Station, North-west of Katherine, has irrigated some 80 ha of sorghum with groundwater from the Daly Basin but the project is not operating in 1972. Bores provide water for horticulture on farms close to Darwin and in the Town and Inner Farm Basins of Alice Springs.

A number of bores were drilled during construction of the sealed roads from Katherine to Wave Hill and from Daly Waters to Borroloola. Mandel (1969) states that the bores were used to water gravel subgrade before sealing, and notes that withdrawals from them are not a permanent feature of the groundwater budget. Mandel (1967) points out that since the inception of cattle trucking along roads such as these, stock routes are now infrequently used although the bores alone, they are maintained.

The non-producing bores mentioned (see p.1) have often yielded valuable groundwater information. The groundwater investigation for the Warrego Mine treatment plant already mentioned was influenced by the yield recorded in a Bureau of Mineral Resources scout hole drilled during earlier
FIG. 1. CROSS-SECTION OF CABBAGE GUM BASIN, N.W.-S.E. (DIAGRAMMATIC)

A. Shatter belt
B1) Fresh granitic rock
B2) Blocks of Warrenunga Group
C. Zone of decomposition of B2 group
D. Superficial deposits
E. Desert sand

(from Brocewell et al., 1962)
The results of regional geological mapping, oil and gas exploration and production wells in the Amadeus Basin yield valuable stratigraphic and groundwater information on aquifers such as the Permo-Triassic Sandstone. Groundwater investigation bore, many of which are permanently equipped with water level recorders, provide most of the available groundwater data in the northern and central parts of the Basin.


deposits of Tertiary and Quaternary age are considered in this category; weathering, profiles are excluded. Porosity in the unconsolidated deposits is therefore primary (or intergranular) and dependent on the degree of sorting.

In the Alice Springs area the use of groundwater from unconsolidated deposits has declined in importance since the discovery and development of the large groundwater resources of the Permo-Triassic Sandstone to supply the town of Alice Springs and irrigation areas south of the town e.g. Undoolya. A number of internal drainage basins containing Tertiary and Quaternary aquifers to the North of Alice Springs are considered to contain irrigation potential by Perry et al (1967), however the quality of this water and its interaction with the soil matrix requires further investigation.

At Tennant Creek where groundwater from the surrounding rocks is generally unavailable and of poor quality, the town water supply comes from unconsolidated deposits in the Cabbage Gum and Kelly Hill Basins. The settlements of the North coast and islands are generally underlain by thick (greater than 5.0 m on Bathurst Island) unproductive Cretaceous sequences and are dependent on the shallow unconsolidated deposits for groundwater.
CABBAGE CUM, KILLY NELL, KILLY WELL V. L. T. BAYING

The Cabbage Cum Basin, about 18 km south of Lemon Creek, was
the first of the three to be developed. The following is from the report

The basin is bounded to the east by the Narramun Group and
close here by granite-mica (see Pi., 4). Its unconsolidated sediments cover
about 50 km² and consist of sand, clay and gravel containing fragments of
fresh and laterized basement rocks. These sediments are up to 20 m thick;
but aquifer material distribution both vertically and horizontally is some-
what irregular. Evidence suggest that there is a westward connection to a
northern outlet of the Kelly Well Basin.

Groundwater movement within the basin is generally east-south-
est along the valley axis. The estimated safe yield for the basin in in
the region of 3,500 m³/week. Until 1968 average weekly extractions totalled
about 3,900 m³ with occasional weekly maximums of 5,500 m³. Transmissivity,
calculated from a series of pumpin tests, ranges from 370 to less than
15 m²/d. Storage coefficient ranges from 2.0 - 3.0 x 10⁻⁴. Water qualities
vary considerably through the area ranging from 360 mg/l total dissolved solids
in the centre of the basin to nearly 10,000 mg/l on the edge of the basin in
the granite aquiclude, with pH less than 7.5 to more than
350 mg/l bicarbonate. Pumping from this basin has slightly increased the
salinity values.

Investigations into the Kelly Well Basin began in 1965.
The following is from the report of Pike (1966).

8/
The basin is 26 km south of Tennant Creek and covers about 26 km². It consists of sediments filling an ancient valley system eroded into the bedrock. These sediments include clays, siltstones, sands, sandstones and gravel. They are essentially unconsolidated but in a zone from 17 to 34 m below the surface they have been silicified and have a very porosity. It is this section that contains the best aquifer, whilst a sandy aquifer immediately above the very layered provides a smaller supply of good quality water.

The volume of the very aquifer is estimated at 280 \times 10^6 \text{ m}^3 whilst the volume of saturated sediment beneath the aquifer is estimated at 310 \times 10^6 \text{ m}^3 giving a combined total of 620 \times 10^6 \text{ m}^3.

Recharge to the basin is via underflow and direct infiltration. Underflow is from the east, south-east and south, and is estimated to be 0.737 \times 10^6 \text{ gpd}. From calculations based on several pumping tests an average value of 750 \text{ m}^2/\text{d} has been adopted for transmissivity and 0.002 for storativity coefficient. Safe yield for the basin has not been calculated but using the derived figures above a figure of 24,000 m³/week would appear to be in order.

Total dissolved solids content ranges from 500 to 5,000 mg/l but over most of the basin is less than 1000 mg/l. The water has a high percentage of bicarbonate ions and contains nitrate and fluoride concentrations that approach the limit for human consumption as set by the World Health Organisation (see Appendix 1).

A further groundwater investigation was carried out in 1971 in the Kelly Well West basin, west of the confluence of Cabbage Gum and Kelly Well Basins. The following is from the report of Rose and Willia (in prep.)
The basin extends 15 km to the west and covers about 40 km². As
in the Kelly Well Basin, the unconsolidated sediments fill an ancient
valley system; they include sands, clays and siltstones. The major aquifers
are siltstone and weathered granite bedrock. The siltstone is of a tubular
nature, silicified and consolidated in some zones (with subsequent reduction
in permeability); it yields up to 1 l/s. Fractures and fissures in the
weathered granite bedrock permit yields greater than 12 l/s.

Total dissolved solids range from 550 – 3,000 mg/l but are less than
1,000 mg/l over most of the basin. High silica and bicarbonate ion con-
centration characterise the water, and both nitrate ion and fluoride ion
concentrations are at or near the limit for human consumption as laid down
by World Health Organization (see Appendix 1).

Recharge to the basin is from underflow and direct surface infiltration.
Underflow from Cabbage Gum and Kelly Well Basins converges in the east and flows
northward for 13 km then north-west towards the Yisc Basin. Direct infiltration
occurs in the south-western corner of the basin and groundwater flows south of
West from here towards a lake which contains water for 8 – 10 months of the
year.

THE ALICE SPRINGS TOWN BASIN

Unconsolidated fluviatile sediments of Quaternary age up to a maximum
thickness of 23 m are preserved in the Alice Springs Town Basin. The following
is from the work of Quinlan and Kooley (1967).

The sediments include gravel, sand, silt and clay and are associated
with past channels of the Todd River. They yield water from permeable beds
of silty sand occurring beneath the piezometric surface. Up to five aquifers
have been postulated; they are recharged from floodwater in certain parts of
the Todd River bed. Calculations indicate that recharge continues for about
100 days after a riverflow, and that the probability of the interval between successive river flows being less than one year is 91. Two figures have been derived for runoff in the Todd River; Wilson (1962) obtained a figure of $2.7 \times 10^6$ m$^3$/year whilst Forbes (1964) had one of $2.3 \times 10^6$ m$^3$/year.

In the Town Basin the recharge source has a definite influence on the chemical quality of the water. Total dissolved solids increase from 250 u/l to 3000 u/g/l with depth and with distance from the Todd River, the source of recharge. This increase is generally accompanied by a change in chemical composition, from a water in which bicarbonate is the predominant anion to water in which no ion is dominant (the mixed type) or to a water in which chloride is predominant. Sodium is the dominant cation throughout the basin.

The volume of water in storage in the Town Basin fell from $3.0 \times 10^6$ m$^3$/year in 1953 to $1.6 \times 10^6$ m$^3$/year in 1964, as a result of an increase in the amount of water pumped from the basin. Average values for the aquifer constants ($450$ m$^2$/d for the coefficient of transmissibility and $0.07$ for the coefficient of storativity) were calculated from aquifer performance tests.

BATHURST ISLAND BASIN

Unconsolidated Tertiary sands occur on Bathurst Island, which is some 64 km North of Darwin. These sands are quartzose, extremely fine grained and very clayey.

Groundwater is recharged solely from precipitation and infiltration. Groundwater movement is away from a central mound and seepage occurs along the surface of the underlying mudstone where this mudstone outcrops. During the 'Dry Season', when water levels drop, no seepage occurs.
In common with other groundwater from unconsolidated sediments along the Northern coast of the Northern Territory, water quality is good except for low pH.

Several production bores have been drilled yielding supplies of 6 l/s. From pumping tests average values of 170 m²/d for transmissivity and 0.00017 for storage co-efficient have been calculated.

TI... BASIN

A large alluvial basin exists at Ti Tree, about 105 km north of Alice Springs. Investigations to assess the groundwater potential of the area for agricultural purposes have indicated that the groundwater is unsuitable for irrigation due to its adverse interaction with soil characteristics.

The basin is filled with unconsolidated material of Quaternary, Tertiary and Cretaceous ages up to 300 m thick. Only the Quaternary sediments contain important aquifers of which the major one is a grey-vugular claystone varying in thickness from 10 to 30 m. It has an average transmissivity of about 450 m²/d gpd/ft, and a storage co-efficient of about 0.03. The overlying brown sandy clay acts as an aquitard.

The estimated storage in the major aquifer beneath an area of 200 km² is 400 x 10⁶ m³, including 160 km² from which supplies up to 4 l/s could be obtained.

Water analyses indicate that most of the water is unsuitable for human consumption, due to a high nitrate and fluoride content and moderate to high total dissolved solids (ranging from 600 mg/l to 2,000 mg/l).
Rocks in sedimentary basins cover approximately 970,000 km² or 70% of the area of the Northern Territory. The rocks considered in this category are generally unmetamorphosed and easily recognizable as sedimentary in origin. Porosity may be primary (intergranular) or secondary (fractures and solution cavities) or a combination of both.

Basins from which major production is occurring are described in detail below.
Table lists the major producing aquifers in the basin. Pocks in this basin are strongly folded and the depth to a particular aquifer is controlled by this fact.

Koreene Sandstone

'collay (1966) describes the hydrology of the Koreene Sandstone and other formations in an area of about 2600 km² about the Todd River, south of Alice Springs. Unless otherwise stated, the following is taken from his work and refers to that area.

The depth to the Koreene Sandstone, the most important aquifer in the area, is controlled by a broad synclinal structure and by the thickness of Tertiary lacustrine deposits and Quaternary fluviatile deposits which infill a trough over 300 m deep, trending east parallel to Todd River. The production bores for the Alice Springs Town Water Supply are included in the area; 'colley and quinn (1970) quote specific capacities for them of between 266 l/s per metre of drawdown.

The potentiometric surface is generally more than 75 m below the surface. Water flow east along the formation from an unknown source (probably local direct infiltration from small streams in the outer area) until it is balanced by water coming in from the overlying Tertiary sediments. Production bores for the town water supply draw on the former water; its flow rate through the aquifer is much greater than the pumping rate (1350 Ml per year in 1966).

The storage coefficient for two production bores in 0.007. The overlying Tertiary sediments however have a storage coefficient of 0.02 and a large estimated storage of 400,000 Ml. The main importance of the groundwater in these Tertiary sediments is as a buffer between the recharge source (Todd River) and the Koreene Sandstone. The large storage in the Tertiary would allow a continuation of flow of water into the latter during a period of several years without any river flow or
other forms of recharge from the surface.

All groundwater from the Kereenie Sandstone in the area is suitable for human consumption, except for one small area of marginal quality. However, the more easterly groundwater is of better quality than that entering via the Tertiary sediments. Colley and Quinlan (1970) note that over the entire Anakie Basin the total dissolved solids in groundwater from the Kereenie Sandstone is generally less than 1000 mg/l and frequently less than 500 mg/l. It rises to 7000 mg/l in one area, where saline water moves into the Kereenie Sandstone from the Ritter Spring Formation across a faulted contact.
Daly, ‘Ire and Georgina Basins

Randal and Brown (1967) consider that the lower Palaeozoic rocks of the Daly Basin merge southwards with those of the ‘Ire Basin and south-eastwards with those of the Parkly Tableland portion of the Georgina Basin. Contours drawn on the base of the lower Middle Cambrian rocks by these authors indicate a north-north-west to northerly trending structural ridge between the ‘Ire and Georgina Basins and a dip northwards from this ridge towards the Daly Basin.

The Daly Basin and most of the Georgina and ‘Ire Basins contain flat-lying or gently warped marine carbonate rocks of Cambrian-Credevian age. Freshwater sandstones of Devonian age occur in the southern Georgina and ‘Ire Basins. Faulting and some associated folding in the former area make the location of aquifers more difficult than in the northerly areas.

Table 2 contains details of the most productive aquifers and their principal areas of use in 1972. Smith (1967) points out that east of longitude 150°E in the Georgina Basin, most bores draw water from overlain Mesozoic rocks of the Yampa Basin.

The basins are discussed under the areas in which they were studied by Randal (1967) and Randal (1969).

Northern ‘Ire Basin, Daly Basin and Georgina Basin (Eastern Parkly Tableland portion)

Unless otherwise acknowledged, the following is taken from the work of Randal (1969).

Three of the major aquifers in Table 2, the Findfall Limestone, the Montejimba Limestone and the 'Anthony Boree Beds are correlatives and tenuously along adjacent parts of the three basins. They can thus be considered hydrogeologically as one rock body. Vertical interconnection of aquifers also exists generally. Targets occur only in some axial
FIG. 2. INTERPRETATION OF LOGS FROM BORES IN THE MONTEJINNI LIMESTONE

(from Randol, 1969)
FIG. 3. INTERPRETATION OF LOGS OF WATER BORES IN THE TINDALL LIMESTONE

To accompany Record 1969/16

(from Randal, 1969)
FIG. 3. INTERPRETATION OF LOGS OF WATER BORES IN THE TINDALL LIMESTONE

To accompany Record 1969/16 (from Randal, 1969)
areas of the Paly Basin where the aquifers of the Callio Limestone are separated from those of the underlying Tindall Limestone by at least 550 m of impervious Jinduckin Formation (Lau, in prep.) and standing water levels differ by about 30 m.

Groundwater is generally sub-artesian and confined. However, unconfined water occurs in the Tindall Limestone between Katherine and Mittawara and south-east of Paly Waters. Artesian groundwater occurs in the Tindall Limestone in the axial areas of the Paly Basin mentioned above (W.R.I. Water Resources Branch, no date).

Recharge is probably effected over a great part of the region as, except in the north-western extension of the Barkly Tableland, there are no closed contours in the potentiometric surface. Direct infiltration into outcrop or sinkholes and percolation through sandy surficial deposits or sinkhole infill seem likely.

Kaweski and Sibley (1970) estimate 750,000 m³ of water in storage within a 3 km radius of the main 'iro production bore 26 km west of 'urogo Mine (near Tennant Creek).

Over most of the region the salinity of groundwater is low (see Map 3): local recharge conditions, shallow groundwater environment and the low salinity of material within the aquifers are probably reasonable. The high salinities of western Barkly Tableland groundwater are an exception.

Bore in the outcrop area of the Tindall Limestone are prone to pollution. The formation is extremely cavernous and probably receives considerable direct recharge through open sinkholes.

Central and eastern Barkly Tableland portion of Scouring Basin

The following gives in abbreviated form the conclusions reached in a study of groundwater in the region by Pandial (1967).

In the central and eastern part of the Barkly Tableland considerable quantities of groundwater are stored in aquifers in the Cambrian marine sequence i.e., the "Cambrian rocks" of Table 2 composed
mainly of carbonate rocks, with subordinate siltstone and sandstone. Although correlation of aquifers from bore to bore is impossible at present, it is apparent that water is stored in several aquifers with some vertical interconnection through cavities, joints, and fissures in the carbonate rocks.

Groundwater is subsurface. The groundwater system is divided into two areas by a ridge in the piezometric surface directed southward from near Alexandria, towards. To the east of the ridge the hydraulic gradient is generally coincident with the drainage directions of the Geelong River Basin, and recharge appears to be mainly from the north and west. To the west of the ridge, the gradient is generally directed towards the Barwon Internal Drainage Basin. Recharge in this area appears to be mainly from the desert area to the south, and the ridges of Precambrian rocks to the east and north-east. There is no evidence of depletion of the aquifers and the comparison between the probable annual recharge and the maximum annual withdrawal indicates considerable reserves for further development of the pastoral industry.

The chemical characteristics of the groundwater in the two areas are similar, but in the western area the salinity (up to 11,000 mg/l) is much higher than in the eastern area (up to 2500 mg/l) as Map 3 indicates. There is a distinct connection between the groundwater flow, as indicated by the piezometric surface, and the salinity. The salinity contours clearly reflect the division of the groundwater system into two areas, and generally trend parallel to the piezometric contours. The same divisions are indicated to varying degrees by the distribution of the individual ions and the ionic ratios. The chemical type of the groundwater, based on the anionic content, conforms to the normal pattern of groundwater flow and distribution with bicarbonate waters in recharge or near-recharge areas and areas of low salinity and chloride waters in areas of assimilation and low hydraulic gradient, and areas of high salinity.
The quality of the groundwater is extremely variable with a salinity range from 31 to about 11,000 mg/l. Over much of the area it is unfit for human consumption because of the high salinity, or the high content of sulphate or fluoride. In this respect, the groundwater in the Barkly Central Plains Basin is the least suitable. Very few of the bores are unsuitable for stock. The waters from many of the bores are of doubtful value for agriculture on the clayey black soils, as they are generally high in sodium relative to magnesium and calcium, and the risk of soil deterioration is high.

The groundwater chemistry appears to be controlled mainly by the hydraulic environment, but some control by aquifer composition is shown by variations of ionic ratios.
The two major aquifers of the basin are listed in Table 3. The following remarks are from the work of Cullinan and Cullinan (1970) on the basin area to the west of the Simpson Desert.

From "Bali Formation"

This formation is tapped for groundwater only along the margins of the basin where the overlying Pama sandstone is not present. The availability of water in it depends largely on the pre-Tertiary topography; relief on this surface is large and successful bores occur where there is sufficient depth below the piezometric surface. The aquifer is generally a medium to coarse grained sandstone.

"Some recharge takes place along the belt of outcrop approximately north-east of Finku.

From "Pama Sandstone"

The pastoral bores in the unit flow. Most however are on the north-western margin of the Fankara Basin where the piezometric surface is below ground level.

Tested supplies range up to 3.8 l/s fromumped bores; the flow at one of the two artesian bores was initially about 40 l/s, but a decline in head from 15 m in 1990 to less than 1.5 m has occurred in this bore.

The total dissolved solids range from about 600 to 3,500 mg/l except to the west of Fulgora where water with over 6000 mg/l occurs (see Map 4).
Although this formation is widely extensive in the "Top Ind", little groundwater is withdrawn from it. Except for local non-marine sandstones in some areas, rocks in the unit contain little primary porosity. Ravenal (1960) considers that in the northern "basin" the unit can usually be considered as unproductive overburden (up to 150 m thick) and that horizons studied in it are likely to obtain water only at or below the underlying unconformity surface.

On the Peninsula, however, the unit supplies both domestic and mine requirements for Hulunbuy.

The Huluman Beds here consist of sandstones (silicified in places to quartzite), siltstone, silts and sandy clays which have a maximum thickness of some 250 m. The aquifer within this sequence in a clean to silty quartz sandstone.

Recharge occurs in the south-eastern part of the Peninsula where the aquifer outcrops in the beds of one or possibly two northernly flowing rivers. Groundwater flows in a north-easterly direction.

Based on existing production bores the average transmissivity is 210 m²/d with a storativity coefficient of about 0.001. Underflow through the basin is estimated at 40 Ml/d.

The groundwater is of low salinity (less than 210 mg/l total dissolved solids) and low hardness. However it contains dissolved carbon dioxide (up to 120 mg/l), a high iron content and some hydrogen sulphide; the water is thus inherently corrosive and "rust" staining occurs if it is aerated. After simple treatment, however, the water is suitable for both domestic and industrial use.
Igneous, metamorphic and highly deformed sedimentary rocks are considered as fractured rocks.

Table 4 lists units for which groundwater resources are known in some detail. Quality of groundwater is shown on Map 4. The groundwater resources of both the Arrin Plateau Volcanics and the Arunta Group are known mainly from bore drilled to supply stock water; those of the Arrazunna Group are known from investigations for water supplies for Tennant Creek and the surrounding mines. The Cornalia Volcanics has provided a supplementary town water supply for Darwin until recently, and about 75 investigation and production bores have been drilled in it over a small area.

**Arrin Plateau Volcanics**

This unit, consisting of flow basalts and some intercalated sedimentary rocks, underlies much of the poor grazing lands of the Victoria River Region. The following is from the work of Kendal (1959) and relates particularly to the unit in the eastern part of that region.

Aquifer type has a major effect on specific capacity: in one bore a specific capacity of 0.05 l/s/m is associated with jointed basalt and in another bore one of 0.7 l/s/m with a sedimentary interbed.

The potentiometric surface is generally less than 50 m below ground level. Interconnection is common in the Volcanics; concurrent joints or interflow zones probably cause it. Discharge to the unit is through direct infiltration of jointed and weathered o turrets in creek beds (clayey soil on most other areas in impervious).

The salinity of most groundwater is less than 2000 mg/l total dissolved solids; high salinities (up to 4000 mg/l) are recorded only from two bores midway between 'Ave Hill and Top Springs homestead. Water from the formation is dominantly a sodium-rich bicarbonate one; this enrichment
in bicarbonate relative to the other major anions indicates proximity of recharge zones to most of the sampling points.

Solution on a local scale is recorded from one bore sited close to areas of organic waste disposal.

Coonlala Complex (Kalinda Lagoon area)

Barclay (1961) states that in this area cavernous dolomite of the Coonlala dolomite underlies molasses and sandstones of the Pleistocene Nullenoo Beds up to 75 m thick. Tumholes are common. Barclay (op. cit.) notes interconnection of cavities in the dolomite. However differences in acidity between surface and underground water samples from the area may indicate that the two waters are not in contact.

Groundwater from the cavernous dolomite is confined. Barclay (op. cit.) considers that groundwater flows to the north-east. Braeswell (1961) considers that recharge—rainfall is secured by non-saline conditions but much of it is probably rejected either because it is too intense or because the aquifer store is full.

Arunta Complex

The moderately to highly metamorphosed rock types of this complex underlie a large area north of Alice Springs and the MacDonnell Ranges.

The following is from the work of Woollard and Quinlan (1970) and refers particularly to the area south of 23°S latitude.

Recharge to the fractured and jointed aquifers is through alluvial deposits in watercourses which cross the aquifers and occurs only for short periods following runoff. Recharge to the weathered rock aquifers probably occurs by the inefficient mechanism of direct infiltration from the surface.

Of the 157 recorded pastoral bores drilled in the unit (see Table 4) only 43 obtained adequate supplies (over 0.5 l/s) of groundwater and in
FIG. 4. INTERPRETATION OF LOGS OF WATERBORES IN THE ANTRIM PLATEAU VOLCANICS
(from Randal, 1969)
6 of them the water was too saline for stock. About half of the 187 bores intersected aquifers which contained salt water. Individual aquifers of the jointed and weathered types lack interconnection; the regional movement of groundwater is thus prevented, the efficiency of the recharge process reduced, and the proportion of dissolved salt increased.

**Warranguma Group**

Francis (1968) states that groundwater from the Warranguma Group is generally of poor quality, with a range of 4,000 - 25,000 mg/l total dissolved solids. We consider that the rocks are poor transmitters of water and notes that Peke Mine is pumped at a rate somewhat less than 460 m³/d to control infiltration into several miles of shafts and drives.

Dawson and Fide (1970) generally concur with the above, but they describe three investigation bores which had yields in the range 1 - 2 l/s (see Table 4). One of the bores has a tested safe yield of 1.9 l/s and supplies "potable water of very good quality" to supplement the domestic requirements at Warranguma Mine. They also note that the Juno Mine shaft intersected fractures yielding a steady water supply of 7.6 l/s; this water contains 5000 mg/l total dissolved solids contrast with 30,000 mg/l in the Peke Mine groundwater mentioned above.
ACKNOWLEDGEMENTS

These notes were prepared at the request of the Senior Engineer (Groundwater), Water Resources Branch for the Groundwater Resources of Australia project of the Australian Water Resources Council. The notes are to be read in conjunction with maps previously prepared for the same project by officers of the branch. The present notes incorporate an earlier draft by A.T. Laws, formerly of the branch. The assistance of other officers of the branch, particularly in metricating all data used, is gratefully acknowledged.
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- Only one value (90) is greater than 1.5 l/s/m² drawdown.
- Minimum specific capacity of bore assuming maximum available drawdown.
- Transmissivity expressed as m²/d.
- 12) Quote from author other than above mentioned.
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<th>v. k.</th>
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<td>Arunta</td>
<td>Plateau</td>
<td>(5) Association of parallel basalt lava flows. Basalt flows have compact medium-grained fresh interior grading into fine-grained, altered vesicular upper and basal portions. Vesicles frequently infilled by secondary minerals. Interstices sandstone, siltstone, limestone and chert beds.</td>
<td>(5) Joint, fracture, porosity zones in vesicular portions of flow and in intercalated sedimentary rock (see Fig. 3).</td>
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<td>Goocaecie Fossilite</td>
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<td>Complex</td>
<td>(22) Metamorphically altered dolostone, dolomite, quartzite and schist.</td>
<td>(27) Fractured and jointed zones (porous to 1.2 m). Weathered zones (to depth 75 m.)</td>
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* For this unit only two values, one each of 0.9 and 1.2, are greater than 0.61/a/a. 
K = Minimum specific capacity at a drawdown of 0.61/a/a. 
T = Transmissivity (m²/d). 
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(5) notes: see correspondingly number in "References cited".
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UC = Uncrastated    S = Sedimentary    F = Fractured
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