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BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

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GROUNDWATER IN THE NORTHERN WISO BASIN AND ENVIRONS, NORTHERN TERRITORY

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SUMMARY

The northern Wiso Basin lies in the central part of the Northern Territory between the Barkly Tableland to the east and the Victoria River district to the west and northwest. Its northern and northeastern limits are the upper reaches of the Daly River system and the Gulf of Carpentaria drainage system. The southern environs (which are not discussed in this Bulletin) are in the semi-desert country between the Stuart Highway in the east and Tanami and The Granites in the west. The region is arid to semi-arid, but nevertheless good grazing lands occur in the eastern, northern, and western parts, and both cattle stations and small townships have been established. Because of seasonal and sparse rainfall the surface water resources of the region are meagre, and both pastoral and community development are largely dependent on the availability of groundwater of reasonable quality.

This study examines the data from over 500 water bores and the regional geological mapping, supplemented by scouthole drilling and 176 chemical analyses of groundwater from selected bores, in an attempt to relate the groundwater regime to the geological environment.

The region comprises three Palaeozoic basins of mainly carbonate rocks and their surrounding Lower Cambrian and Precambrian basement rocks. From a groundwater point of view the most important of the basement rocks are Lower Cambrian volcanics, which crop out in the west and extend subsurface considerable distances eastward. Most of the groundwater is obtained from the carbonate sequences. Over large parts of the region these sequences are overlain by flat-lying Lower Cretaceous rocks which have a profound effect on the groundwater regime.

Geomorphology also is important to the groundwater regime. The region is a gently undulating plateau which slopes northward and is bounded by the dissected country of the main coastal river systems; depth to economic quantities of water is governed by the depth below the surface of suitable aquifers, and throughout the plateau these are generally deeper than on its dissected margins.

The main aquifers occur in volcanic and carbonate sequences, and about the dissected margins the groundwater regimes of both are very similar because they are both relatively close to recharge zones. The salinity of the groundwater in these situations is low. Beneath the Lower Cretaceous rocks and in the plains country in the southeast, many bores in the carbonate rocks tap groundwater which has travelled considerable distances from recharge zones and accordingly is saline. But throughout the entire region the known groundwater reserves are suitable for stock; only in a few places is the quality below domestic standards.

The availability of groundwater varies through the region, depending on the principal geological control. Water is stored in the volcanics in joint and fracture zones and the supplies are related to their incidence below the watertable in the borehole intersection, and the presence of recharge paths to them. Good supplies have been obtained, but poor supplies and failures are common. Recent work has shown aquifers to be stratigraphically controlled overlapping flows and sedimentary interbeds. Additional work on these aspects may minimize unsuccessful drilling. The water in the carbonate rocks is stored in cavities and joints, considerably enlarged because of the solubility of the rock, and hence providing greater storage and supply than the volcanics. Furthermore, recharge is probably more effective because of open sinkholes and joints in karst topography.

The Lower Cretaceous rocks are generally poor aquifers. Although the sequence contains a basal sandstone of good aquifer characteristics beneath impermeable claystone units, it is generally above the potentiometric surface and stores little water. Bores begun in the Cretaceous rocks commonly need to be drilled over a hundred metres to reach the more favourable underlying carbonate formations.

The groundwater resources are more than adequate for the present pastoral and community development. Although rainfall is low in the southern parts the probable recharge areas are very large and the withdrawal rate is very low. In the north rainfall is high and recharge situations extensive. Isolated cases of overdevelopment or failure of existing bores may occur, but these are mainly due to poor bore site locations and completion rather than to depletion of resources. Pollution may be a hazard at settlements where local recharge to groundwater occurs, particularly in the areas of karst carbonate outcrops.

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INTRODUCTION

Geography

The Wiso Basin, which contains mainly lower Palaeozoic rocks, occupies a region between the Stuart Highway and the eastern and southern watershed of the Victoria River, and lies between latitudes 15°S and 21°S in the Northern Territory of Australia. The name is derived from the Wiso Tableland, a term used by Hossfeld (1954) to describe the elevated desert country between Newcastle Waters, Wave Hill, The Granites, and Barrow Creek. Hossfeld believed that the Tableland was underlain by Cambrian sediments continuous with those in the Buldiva Basin to the north—the whole sequence occurring in the Buldiva-Wiso Basin. Hossfeld's term 'Buldiva Basin' refers to the Daly River Basin of Noakes (1949); most workers have followed Noakes' terminology but have simplified the name to Daly Basin.*

The western environs of the Wiso Basin are the country east of the Victoria River to the edge of the Wiso Tableland; the northern are the southern parts of the Daly River Basin and the southern headwaters of the Roper River system; and the eastern are the western and northwestern parts of the Barkly Tableland (Fig. 1). The southern part of the Wiso Basin and its southern environs—desert country of little pastoral value and few bores—are not discussed in this report.

The northern Wiso Basin and its environs cover about 195 000 km^2, and includes the following 1:250 000 Sheet areas: Tanami East, Green Swamp Well, Winnecke Creek, South Lake Woods, Helen Springs, Beetaloo, Newcastle Waters, Tanumbirini, Daly Waters, and Larrimah; it also includes portions of the Tennant Creek, Hodgson Downs, Katherine, Fergusson River, Delamere, Victoria River Downs, and Wave Hill 1:250 000 Sheet areas.

The two major road networks of the northern part of the Northern Territory traverse the region: the Stuart Highway from Darwin to Alice Springs traverses the eastern part, together with the Roper River Road from Mataranka, the Borroloola Road from near Daly Waters (also known as the Cape Crawford Road), and the Barkly Highway to Mount Isa from near Tennant Creek; and the road networks from Katherine to Western Australia via Willeroo and Timber Creek and via Willeroo and Wave Hill cross the northwestern and western parts. A main road from Dunmarra on the Stuart Highway to Top Springs connects the eastern and western road networks: it replaces the historic Murranji Track to the south, which is now infrequently used. Most of these are all-weather roads, but some low-level crossings are impassable for short periods after heavy rain. The Stuart and Barkly Highways and the road from Katherine to Top Springs are bitumen-sealed.

The major settlements are the townships of Katherine, Tennant Creek, Daly Waters, Larrimah, Mataranka, Elliott, and Newcastle Waters. Larrimah†, Mataranka, and Katherine are linked to Darwin by the North Australian Railway, and all the towns are situated near important road junctions. Tennant Creek, Daly Waters, and Katherine are served at least twice a week by Australia's two main

* This name refers to the geological basin; the term Daly River Basin is used for the physiographic entity, which is approximately coextensive with the geological one.

† Larrimah is now the virtual railhead; although the railway continues on to Birdum, which is in ruins, the line is not used.

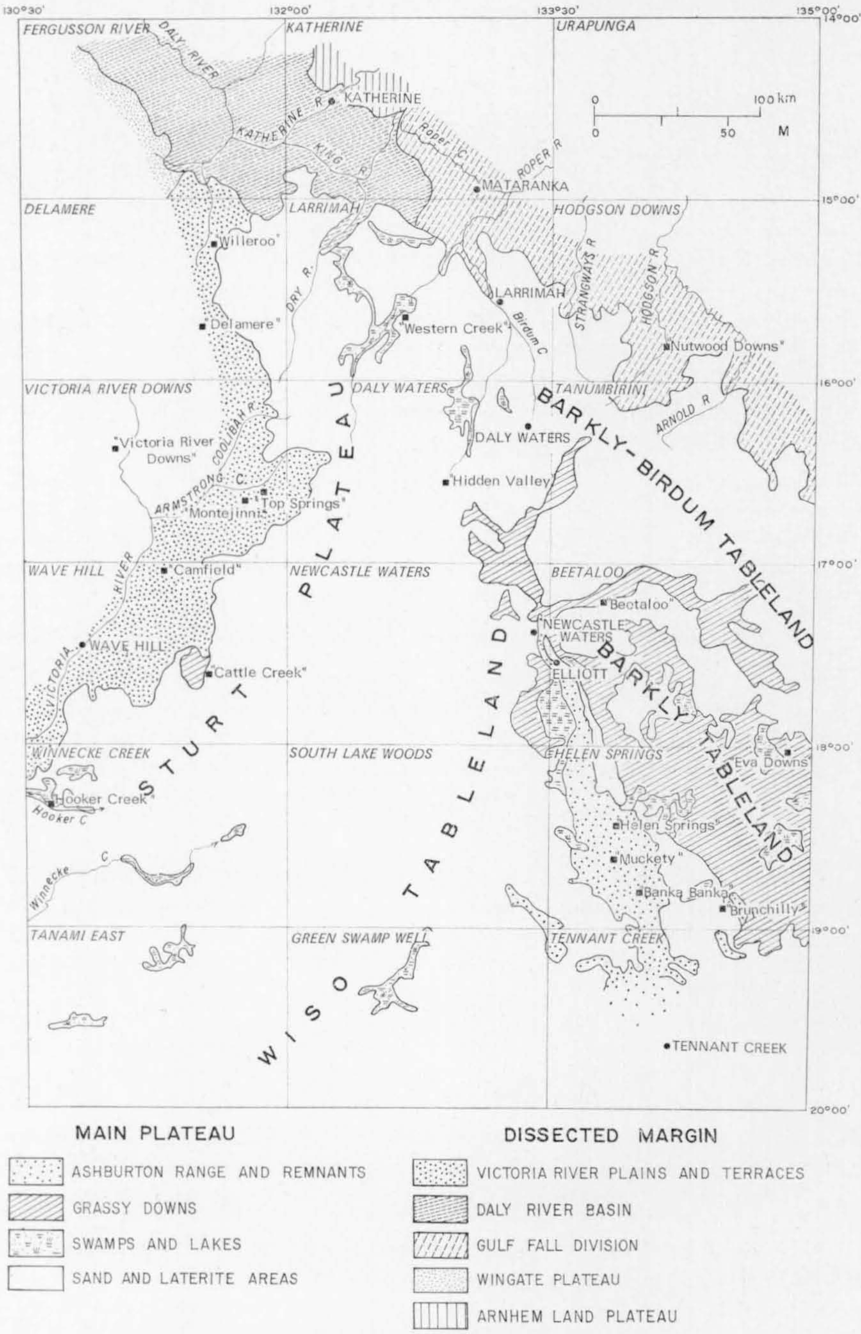

Fig. 1. Physiographic map.

commercial airlines. Other settlements, apart from cattle stations, are the small township of Top Springs in the west, the Native Settlements (Welfare Branch, Northern Territory Administration) at Wave Hill, Hooker Creek, and Beswick, and two roadside inns on the Stuart Highway. The many cattle stations in the region are mainly in the dissected western and northern margins, in the Barkly Tableland and its northern extension, and along the Stuart Highway. There are no stations south of the Murranji Stock Route in the semi-desert area between Tennant Creek and Hooker Creek: it contains few well defined watercourses, no permanent waterholes, and only inferior grazing land. Most stations are regularly served by light aircraft operating from either Alice Springs or Darwin. Stations along the Stuart Highway have a telephone service: the others are in radio communication with Alice Springs, Wyndham, or Darwin. With the exception of a few small farms and agricultural research stations about Katherine township, there is no intensive agriculture.

There are several important stock routes in the region: the Barkly Stock Route near Elliott eastward to Eva Downs and beyond to Queensland; a stock route from Mataranka eastward along the Roper Valley; the North-South Stock Route from the Barkly Stock Route near Helen Springs homestead southwards approximately along the Stuart Highway to Alice Springs; the Birdum Stock Route from near Larrimah, also approximately along the Stuart Highway southwards to Newcastle Waters, and its northern extension to Katherine via Mataranka and Maranboy; the Murranji Stock Route from Newcastle Waters to Top Springs; the Dry River Stock Route from Katherine along the valley of the Dry River to Top Springs; the Wave Hill Stock Route from Top Springs to Wave Hill and beyond to the west; the Auvergne Stock Route westward from Top Springs; the Coolibah Stock Route from Katherine to Coolibah via Willeroo; a stock route connecting Willeroo to Wave Hill through Victoria River Downs; and the South Barkly Stock Route eastward from Attack Creek on the Stuart Highway and passing between the Brunchilly/Rockhampton Downs Road and the Barkly Highway. Since droving has been superseded by trucking these routes are little used, except where they follow the made roads, but the watering facilities along them are still maintained, and some are leased to the surrounding cattle stations.

The climate of the region is discussed in the chapter on surface water.

Previous Investigations

Geological

The entire region illustrated on Figure 1 has been mapped at 1:250 000 scale by the Bureau of Mineral Resources, and all the geological maps are available at this scale except Tennant Creek. The sheet areas within the Wiso Basin south of latitude 18°S were mapped in 1965 (Milligan, Smith, Nichols, & Doutch, 1966), and the maps are available in the preliminary geological series at 1:250 000 scale and as a composite at 1:1 000 000 scale. During this work part of the western part of the Tennant Creek Sheet area was mapped.

Also in 1965, the Helen Springs and Beetaloo Sheet areas and the eastern portion of the Tennant Creek Sheet area were mapped as a continuation of the regional mapping of the Barkly Tableland portion of the Georgina Basin (Randal, Brown, & Doutch, 1966).

The Helen Springs and Beetaloo geological Sheets are published in the standard edition series at 1:250 000 scale (Randal & Brown, 1969; Brown & Randal, 1969). The northern part of the Wiso Basin—between latitudes 15°S and 18°S, and west of longitude 133°30′E—was mapped in 1966 (Randal & Brown, 1967) in an attempt to establish the relationships between the Middle Cambrian rocks of the Wiso, Daly, and Georgina Basins. The Newcastle Waters and Larrimah (Randal, 1969a, b) and Daly Waters (Brown, 1969) 1:250 000 geological Sheets are published. Only the eastern portions of the Wave Hill, Victoria River Downs, and Delamere Sheet areas were mapped in 1966—these have been issued as composite photogeological and preliminary 1:250 000 Sheets, and final coloured editions are (1972) in press.

The Fergusson River (Randal, 1962) and Katherine (Randal, 1963) Sheet areas were mapped during the regional mapping of the Katherine/Darwin Region between 1953 and 1959 (Walpole, Dunn, & Randal, 1968). The Tanumbirini (Paine, 1963) and Hodgson Downs (Dunn, 1963a) Sheet areas were mapped during the regional study of the Carpentaria Proterozoic Province which lies between Arnhem Land and the Queensland Border. Within the area of the Palaeozoic basins several oil companies have carried out supplementary geological and geophysical investigations, and the entire region has been covered by helicopter gravity traverses by contractors for the Bureau of Mineral Resources (Flavelle, 1965; Whitworth, 1970).

Earlier investigations in the region are referred to and incorporated in the reports listed above.

Hydrogeological

In 1909 Chewings (1930, 1931) passed through the southern part of the region during a survey for bore sites between Barrow Creek and Wave Hill, and constructed small wells and carried out shallow boring at selected sites. Winters (1915) journeyed along the Overland Telegraph Line from Pine Creek to Newcastle Waters in 1914; he contributed notes on the Cambrian and Cretaceous rocks, and commented on the groundwater environment along the route, which he considered similar to that of the Barkly Tableland. Woolnough (1912) and Jensen (1915) passed through the eastern part of the region and commented on the Cambrian geology and the subartesian water resources of the Barkly Tableland. Ward (1926) travelled through much of the region during 1925 and collected bore data and selected bore sites along several of the stock routes.

Between 1949 and 1953 Traves (1955) examined the western portion of the region during the geological reconnaissance of the Ord/Victoria Region, and also examined water supply problems at Wave Hill station (Traves, 1953). Since 1950 resident geologists of the Northern Territory Administration (NTA) and the Bureau of Mineral Resources (BMR) have selected bore sites and provided geological opinions on bore sites for pastoralists in the region. Most of these investigations are described in file notes and have not been prepared as complete reports. However, Barclay & Hays (1965) reported on groundwater investigations carried out on Victoria River Downs and Wave Hill stations in 1963, and Mackay (1957) on groundwater investigations on Nutwood Downs and Manbulloo stations. Both Barclay & Hays and Mackay describe the difficulties of obtaining supplies of water from volcanic sequences. Laws (1967) gives a preliminary appraisal of the hydrogeology of the Daly River Basin and sets out the current program of investigation by the Water Resources Branch of the Northern Territory Administration. He has also made (NTA & BMR file notes) a reappraisal of the results of ten bores drilled along the Daly Waters/Borroloola Road (Cape Crawford Road) in the Daly Waters and Tanumbirini Sheet areas.

Noakes (1954), Traves & Stewart (1954), and Randal (1967) examined the groundwater regime of the central and eastern Barkly Tableland, and their work has some bearing on the eastern part of the region illustrated in Figure 1.

This report discusses groundwater data obtained by the author in 1965 and 1966 during the regional mapping of the western Barkly Tableland and the northern part of the Wiso Basin, and incorporates information obtained by Milligan, Smith, Nichols, & Doutch (1966) during scouthole drilling in the Wiso Basin in 1965.

PHYSIOGRAPHY

There are two major physiographic units: a gently undulating plateau with sparse surface drainage and a dissected area bordering it on the west, north, and northeast (Fig. 1). These two units are respectively parts of Hays' (1967) 'Main Plateau' and 'Dissected Margin' of the northern part of the Northern Territory.

The Main Plateau

Different names have been used for different parts of the Main Plateau. Hossfeld (1954) used the term Wiso Tableland for the area between Newcastle Waters, Wave Hill, The Granites, and Barrow Creek. The term therefore covers the southwestern quarter of this region. Traves (1955, fig. 6) uses the term Sturt Plateau for the western part of the Main Plateau, from north of Willeroo to south of Hooker Creek Settlement. There is no definition for the eastward extension of Traves' unit, but it is clearly implied that it continues eastward of the border of his map—longitude 132°E. Dunn (1963a) and Paine (1963) referred to the plateau on the Hodgson Downs and Tanumbirini Sheet areas as the Barkly/Birdum Tableland; this term is used by Dunn, Smith, & Roberts (in prep.) for the elevated country lying between the headwaters of streams flowing to the Gulf of Carpentaria and the grassy downs of the Barkly Tableland, and trending southeastward from the southern headwater tributaries of the Roper River. It is continuous with the northern part of Traves' Sturt Plateau. The Barkly Tableland is shown on most maps of the Northern Territory as extending southeastwards from near Newcastle Waters to the valley of the Georgina River and beyond into Queensland. It includes the vast grassy treeless downs of the black-soil plains and their margin of sandy areas covered by low scrub. Randal (1967) states: 'It is difficult to define the Barkly Tableland as a physiographic entity', and supports Noakes' (1954) opinion that the term 'Tableland' is a misnomer. The portion of the Barkly Tableland in the region is part of the Barkly Internal Drainage Basin of Noakes (1954) and Randal (1967)—a long shallow depression extending for 440 km southeast from Newcastle Waters and containing unconnected endoreic and areic drainage. Although these various names refer to true physiographic division of the regions in which they were originally applied, within the region discussed in this Bulletin they are merely local geographic terms for the same thing—Hays' Main Plateau—and have no natural demarcation*. Hays' term is preferred as it emphasizes the regional extent of the plateau, but the others are used here for convenience of reference.

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* A possible exception is the Barkly Tableland, which here virtually coincides with the grassy downs, which have been treated as a subdivision of the Plateau. Hays' definition of the Main Plateau clearly includes the Barkly Tableland and there is no justification for treating it as a separate major unit.

The Main Plateau is divided into four minor units:

1. The Ashburton Range and its remnants occur in the southeast: the unit consists of dissected strike ridges and plateaux of Precambrian sandstone and siltstone of the Tomkinson Creek Beds. The hills rise up to 90 m above the surrounding sandy plains. The summit surface is about 360 m above sea level at its highest point and slopes northwards. Remnants of this surface, which Hays (op. cit.) called the Ashburton Surface, occur in the southwest of the region. Hays considered the Ashburton Surface to be older than Lower Cretaceous, and Randal et al. (1966) cite supporting evidence.

2. Less resistant intervals in the Tomkinson Creek Beds are eroded preferentially into broad valleys, generally parallel to the strike of the rocks. However, the main drainage of the Range is at right angles to the strike, and the streams terminate either in floodouts in the flanking sand plains, or in swamps and lakes in the downs country.

3. The grassy downs occur in the eastern part of the region. The unit consists mainly of treeless black-soil plains, although low stunted trees and shrubs occur in the valley of Newcastle Creek, and is developed over Cambrian and Tertiary carbonate rocks and Lower Cretaceous siltstones. The downs country has low relief with broad, low rises and closed drainage basins of varying size, fed by widely spaced non-perennial watercourses. Small gravelly rises and patches of sandy soil are common. The main downs area is the northwestern limit of the Barkly Tableland and is a line or depression, ranging from 195 m to 225 m above sea level. Farther north the downs attain an elevation of about 240 m. To the east they form part of the Barkly Internal Drainage Basin (Randal, 1967) which contains numerous swamps and lakes.

4. Swamps and lakes occur in the eastern part of the region both in the downs and flanking the Ashburton Range, and in the sand and laterite areas in the north, southwest and south of the Main Plateau. Many small ones are not shown on Figure 1 or Plate 1. The swamps and lakes are the foci for the endoreic drainage systems of the Plateau, although in places they are simply alluvium-choked depressions at gradient changes in streams which ultimately flood out many kilometres farther downstream. They contain reworked clayey black soil, and silt and sand-size particles of Recent alluvium. They support a growth of bluebush, swamp flinders grass, and various types of reeds and swamp shrubs.

The sand and laterite areas occupy the greater part of the Main Plateau. Laterite occurs mainly north of the Murranji Stock Route and in the Barkly-Birdum Tableland, although in the predominantly sandy areas to the south admixed laterite gravel or lateritic rises are not rare. The laterite areas in the north consist mainly of low rises covered with ironstone pisolites and thin soils, separated by wide valleys with a thick cover of reddish sandy and loamy soils. The valleys have a system of tributary valleys, but most no longer contain active streams. The ancient streams which occupied these sandy valleys strongly dissected the laterite rises, and now, apart from the lack of sand dunes, the northern area of sand and laterite is very similar to that in the south. Probably owing to the higher rainfall the vegetation is denser in the north: grassy savannah woodlands of turpentine, acacias, and eucalypts, and open plain in the north, and turpentine and wattle scrub with spinifex in the south. A piedmont sand plain flanks the eastern side of the Ashburton Range.

The surface of the Main Plateau has a general northward slope, but strong undulations in it markedly influence the drainage. Elevated country occurs immediately to the north of the valley of Newcastle Creek, and discontinuously, as outlined by the 245 m contour (see Pl. 1), strikes westward to the margin of the Plateau and acts as a divide between exoreic streams flowing northward to the coast and endoreic streams flowing towards a zone of depressions outlined by the 210 m contour between Lake Woods and Cattle Creek. Possible downwarping in this zone and headward erosion have made Cattle Creek an exoreic stream which, by further headward erosion, may capture and change the course of the essentially endoreic Hooker Creek. South of this zone between the Barkly-Birdum Tableland and Top Springs homestead the Main Plateau maintains its northward decline and the major streams are directed towards the Gulf Fall Division and the Daly River Basin. In the upper reaches the streams are not well defined and their beds become lost in alluvium-choked valleys, but towards the Plateau edge they become moderately well entrenched and do not cross it with any great change in gradient. Furthermore, the headward erosion by these streams coupled with the northern slopes of the plateau have destroyed the escarpment of the Plateau in many places so that the Plateau margin is ill defined. Numerous small watercourses on the northern slopes of the Plateau are areic.

The Dissected Margin

The country marginal to the Main Plateau is dissected by the streams of three major drainage systems: the Victoria River, the Daly River, and the rivers flowing northward and eastward to the Gulf of Carpentaria. Consequently the Dissected Margin can be readily subdivided into divisions previously erected by other marks: the Victoria River Plains and Terraces (Traves, 1955), the Daly River Basin (Noakes, 1949), and the Gulf Fall Division (Stewart, 1954). In the northwest of the region the Daly River Basin is flanked by the Wingate Plateau and its marginal tablelands (Randal, 1962). The Wingate Plateau is not relevant to this discussion and is shown merely to illustrate the margin of the Basin; it is not further discussed. Neither is the Arnhem Land Plateau, which partly flanks the Basin on the east. Further regional aspects of the drainage systems are discussed in the chapter on surface water.

Victoria River Plains and Terraces

These flank the entire western margin of the Main Plateau. They are formed by subhorizontal bedded volcanics and sediments of Lower Cambrian age and, in places near the scarp, Middle Cambrian carbonate rocks. Resistant bands form terraced mesas and plateaux, but the main topographic units are undulating rounded hills and stony plains. The vegetation is mainly open forest grasslands and grasslands. The topography is controlled by differential erosion. Stream trends appear to be controlled by jointing and many streams trend at 130°. Some of the long straight reaches of the major streams may be controlled by faulting: a prominent feature is a lineament along the Victoria River from northwest of Hooker Creek Settlement to near Camfield homestead; from there it follows the Armstrong River and Coolibah Creek to the edge of the Plateau, thence downstream along the Dry River to the King River, and then along the upper reaches of the King River into Arnhem Land. This major trend is reflected by many streams both in this division and also within the Plateau.

Daly River Basin

This is developed in lower Palaeozoic sandstone, siltstone, and carbonate rocks; its headwater margins are in Lower Cambrian volcanics and Precambrian sandstone, siltstone, and granite; residuals of Lower Cretaceous rocks occur throughout the Basin. Differential erosion, though evident, is not the main topographic control. The Daly River and the lower courses of its tributaries have broad sweeping meanders, but the topography is not as mature as it appears. Erosion of the Basin is retarded by high country of Precambrian rocks which forms a barrier across the Daly River downstream beyond the region. Furthermore, because of the horizontal strata within the Basin, which have themselves encouraged the development of meanders, the streams must initially cut through all the flat-bedded rocks, and usually cannot evade more resistant rock types by changing course into softer material until considerable downcutting and scarp retreat has occurred. Hence local base levels have been imposed on them and small falls and rapids are characteristic. Despite this, the rocks of the basin, being mainly soluble limestones and soft friable sandstones, are more susceptible to erosion than the harder rocks of the adjoining Wingate and Arnhem Land Plateaux.

In the Daly River Basin the sandstones and interbedded carbonate rocks of the Jinduckin Formation occur as rounded hills and mesas; the shales are preferentially eroded, particularly in the upper reaches of streams. The carbonates of the Tindall Limestone occur as heavily dissected karst outcrops and boulders and slabs. Sinkholes and caves are common, and together with reasonably permeable soils give considerable subsurface drainage. The surface drainage is consequently dendritic and scanty. The Mullaman Beds form the northern foot of the Main Plateau and remnants of it occur as isolated mesas and buttes. The vegetation is mainly low scrub and open savannah woodlands with various types of grasses.

Landforms in the northwestern part of the *Gulf Fall Division* in the region (particularly along the Roper Valley) are very similar to the Daly River Basin and the northeastern part of the Main Plateau, mainly because of the underlying flat-bedded Lower Cretaceous Mullaman Beds and the Middle Cambrian Tindall Limestone, which occur beneath all three land divisions. Farther to the east and southeast the division is moderately dissected. Topography reflects differential erosion of various rock types and is strongly controlled by jointing and geological structure. The Bukalara Sandstone forms a dissected tableland with incised gorges marginal to the Main Plateau; and the Nutwood Downs Volcanics with adjoining outcrops of the Bukalara Sandstone form the drainage basin of the Upper Hodgson River in country similar in landform to the undulating rounded hills of the Victoria River Plains and Terraces. The streams are well defined and dendritic.

GEOLOGY

The region occupied by the northern Wiso Basin and environs contains rocks of Precambrian, Palaeozoic, Mesozoic, and Tertiary ages, but there is an extensive cover of Cainozoic superficies (Pl. 1). A summary of the stratigraphy is given in Table 1.

There are three Palaeozoic basins of mainly carbonate deposits in the study area—the Wiso Basin in the south and central west, the Daly Basin in the north, and the Georgina Basin in the central east and southeast. The Wiso and Georgina

TABLE 1. STRATIGRAPHY OF THE NORTHERN WISO BASIN AND ENVIRONS, NORTHERN TERRITORY

Era	*Period*	*Stratigraphic unit and symbol*	*Distribution*	*Lithology*	*Maximum known thickness (m)*	*Topography*	*Remarks*
		Superficial deposits	Widespread			Various	
		Cza		Alluvium	3		
		Czb		Black soil	6		
		Czt		Travertine	3		
		Czs		Sand, sandy soil, pisolitic lateritic gravel	24		
CAINOZOIC	TERTIARY	Golliger Beds Tg	Tanumbirini Sheet area	Impure grey limestone	3	In shallow depressions	Abundant gastropod and plant remains
		Brunette Limestone Tb	Helen Springs Sheet area	White limestone with chalcedonic silica nodules and laminae; some massive chalcedony, minor sandstone	5	Low rises in downs country	Gastropods and forams
		Birdum Creek Beds Ti	Larrimah Sheet area	White limestone and chalcedony	15	Low rises and rubble in black soil plains	Gastropods
		Camfield Beds Tc	Wave Hill Sheet area	Conglomeratic limestone and calcilutite with chalcedony, siltstone, sandstone	21	Low hills and mesas	Vertebrate bones and gastropods
		Tt	Southern and southwestern part of region	Limestone, sandstone, claystone	27?	Low karst outcrops	
MESOZOIC	LOWER CRETACEOUS	Mullaman Beds Klm	Northern and eastern parts of region	Sandstone, mudstone, claystone	145	Escarpments on plateau edges, rocky knolls on plateau, mesas	Contains fossiliferous freshwater unit overlain by fossiliferous marine units
		M	Helen Springs Sheet area	Sandstone, pebble and boulder conglomerate, siltstone	24	Laterite capped plains and residual mesas in major valleys within the ranges	Plant impressions
PALAEOZOIC	UPPER DEVONIAN	Dulcie Sandstone Dud	Tanami East	Quartz sandstone, argillaceous sandstone	18	Bluffs	
	LOWER ORDOVICIAN	Oolloo Limestone Olo	Katherine and Fergusson River Sheet areas	Limestone, cherty and silicified in places, dolomite	60?	Karst outcrops	

Era	*Period*	*Stratigraphic unit and symbol*	*Distribution*	*Lithology*	*Maximum known thickness (m)*	*Topography*	*Remarks*
PALAEOZOIC	CAMBRIAN OR ORDOVICIAN	Jinduckin Formation G/Oj	Extensive outcrops in Daly River Basin	Sandstone, siltstone, dolomite, dolomitic limestone, marl, silicified limestone	At least 139	Mesas and rocky hills. Some outcrops in stream banks	Upper beds contain Lower Ordovician fossils. No apparent break with underlying Middle Cambrian rocks
		Manbulloo Limestone Member G/Ou	Daly River Basin	Dolomite and dolomitic limestone, limestone	60?	Mesas	Local development of carbonate rocks of Jinduckin formation
PALAEOZOIC	MIDDLE CAMBRIAN	Merrina Beds Gme	Extensive outcrops in southern and south-western part	Dolomite, dolomitic siltstone, sandstone, siltstone, chert	235	Undulating desert country. Low hills and rises	Lower part of sequence probably correlate of Montejinni Limestone
		Anthony Lagoon Beds Gmy	Helen Springs and Beetaloo Sheet areas	Feldspathic sandstone; chocolate and red siltstone, often calcareous and dolomitic; limestone, dolomitic limestone, dolomite	90+	Low rubbly rises	Contains unidentifiable fragments of echinoderms, trilobites, and brachiopods. Regarded as early Middle Cambrian
		Tindall Limestone Gmt	Daly River Basin, and headwaters of Roper valley. Probably occurs in subsurface as far south as Newcastle Waters	Limestone, dolomitic limestone, dolomite	910	Karst outcrops. Grassy plains and woodlands	Contains early Middle Cambrian fossils. Equivalent to Gum Ridge Formation
		Gum Ridge Formation Gmg	Within and marginal to Ashburton Range	Siliceous shale and chert, sandstone, limestone and altered carbonate rocks. Limestone, dolomite, chert, dolomitic limestone in subsurface	52	Low rubbly rises	Contains early Middle Cambrian fossils
		Montejinni Limestone Gmm	Longitudinal belt in western part of area	Limestone, dolomite, calcareous siltstone, mudstone, chert	60	Karst topography or savannah	Contains early Middle Cambrian fossils. Contains three units which are discussed in the text

Era	Period	Stratigraphic unit and symbol	Distribution	Lithology	Maximum known thickness (m)	Topography	Remarks
PALAEOZOIC	LOWER CAMBRIAN	Antrim Plateau Volcanics Gla	Western and north-eastern part of region. Known in subsurface in central part of region	Basalt, trachite, tuff agglomerate, sandstone, limestone, chert, siltstone	245	Rounded, blocky hills, ill defined plateaux and mesas	
		Nutwood Downs Volcanics Glm	Hodgson Downs Sheet area	Basalt, andesite agglomerate, tuff, sandstone	122	Low rounded hills	Presumably continuation of Antrim Plateau Volcanics from the north, and from (subsurface) the west
		Helen Springs Volcanics Glh	Helen Springs Sheet area	Basalt, sandstone, siltstone	37	Rounded hills and ill defined mesas	Probably equivalent to Antrim Plateau Volcanics
		Bukalara Sandstone Glb	Hodgson Downs Sheet area	Quartz sandstone, siltstone	60	Tableland	
		Pzl	Southwestern corner of the region	Limestone, dolomite, sandstone, siltstone		Low hills	Overlain by Dulcie Sandstone. May be equivalent to Middle Cambrian Merrina Beds or Ordovician Hanson River Beds (Milligan et al., 1966)
PRECAMBRIAN	LOWER PROTEROZOIC	Tomkinson Creek Beds* (Plt)	Southeastern part of region	Quartz sandstone, siltstone, carbonate rocks, leached carbonate rocks, chert, minor conglomerate. Dolerite sill. Volcanics in Tennant Creek Sheet area	15 240?	Sandstone forms strike ridges, siltstone and carbonates occur in valleys	

* This is the only Precambrian unit whose groundwater potential is discussed in detail in this report. The Precambrian units on the western and eastern margins of the Palaeozoic sequence are only briefly referred to in the text: their stratigraphy is described in the references cited throughout the text.

Basins are separated in the south by Precambrian rocks. To the north these two basins and the Daly Basin appear to merge, but the contacts are obscured by a large area of Cretaceous sediments which are nearly 150 m thick. The Palaeozoic basins are bounded on the west and the east by Lower Cambrian volcanic rocks and by Precambrian arenite and carbonate sequences of the Victoria River and McArthur Basins respectively.

PRECAMBRIAN

The Precambrian rocks on the western margin of the region consist of sandstone, siltstone, and carbonate rocks of the Victoria River Group (Traves, 1955) and the Tolmer Group (Randal, 1962), and undifferentiated greywacke, schist, and intrusives in the southwest mapped by Milligan et al. (1966). The groundwater resources of the Tolmer Group and the undifferentiated rocks are not discussed in this report and those of the Victoria River Group only briefly. Geologists of the Mines Branch, Northern Territory Administration, are compiling considerable information about the groundwater potential of both the Victoria River Group (J. Shields, NTA, pers. comm.) and the Tolmer Group (Laws, 1967).

In the northeast the Palaeozoic succession is bounded by the Lower Proterozoic Finniss River Group, the Carpentarian Katherine River and Mount Rigg Groups, and the Adelaidean Roper Group. The Finniss River Group consists of mainly greywacke and siltstone with subordinate volcanics deposited in the trough of the Pine Creek Geosyncline (Walpole, Dunn, & Randal, 1968; Randal, 1963). The Katherine River and Mount Rigg Groups both consist of a mainly arenite-volcanic sequence overlain by a clastic-carbonate sequence deposited in the western part of the McArthur River Basin (Dunn, Smith, & Roberts, in prep.; Dunn, 1963a, b; Paine, 1963). The Roper Group overlies the Carpentarian rocks and consists of a sandstone-shale sequence with subordinate carbonate rocks. The groundwater resources of these four groups are not discussed in this report.

In the southeastern part of the region the rocks of the Wiso and Georgina Basins are separated by the Lower Proterozoic Warramunga Group cropping out about Tennant Creek, and the Lower Proterozoic Tomkinson Creek Beds, which form the Ashburton, Short, and Whittington Ranges between Tennant Creek and Newcastle Waters. The Warramunga Group (Ivanac, 1954; Crohn & Oldershaw, 1965) consists of greywacke, siltstone, and shale deposited in the Warramunga Geosyncline (Noakes, 1953). Its groundwater resources are not discussed here. The groundwater contained in it varies considerably in quality and availability; these aspects are briefly mentioned by Bracewell, Crohn, & Hays (1962).

The *Tomkinson Creek Beds* (Randal et al., 1966)* are a sequence of mainly sandstone and siltstone, but contain subordinate chert, carbonate, and conglomerate beds. The stratigraphy of the rocks is imperfectly known as, according to Randal et al., the rocks crop out in four structurally separate blocks, and beds can be traced between two of them. Nevertheless Randal et al. suggest a possible correlation between all four blocks and estimate the thickness of the unit at 50 000 ft (15 000 m). The oldest part occurs west of the Stuart Highway, south of Muckety homestead, in the northern part of the Tennant Creek Sheet area. The youngest rocks crop out in the Beetaloo and Newcastle Waters Sheet areas.

* This unit was named Ashburton Sandstone by Noakes & Traves (1954), but the name was invalid and the unit was renamed (Randal et al., 1966; Randal & Brown, 1969).

The Tomkinson Creek Beds consist mostly of fine, medium, and coarse, clean quartz sandstone, but throughout the sequence there are beds, several hundred metres thick, of pebbly sandstone or conglomerate and argillaceous sandstone. Siltstone beds up to 400 m thick occur throughout the sequence. Chert, derived from the alteration of carbonate rocks, occurs extensively southwest of Banka Banka homestead; limestone and leached carbonate rocks occur in the headwaters of Bootu Creek, east of Muckety homestead; dolomite, limestone, dolomitic limestone, and calcareous sandstone occur southeast of Helen Springs homestead and west of Renner Springs; and chert and leached carbonate rocks are common in the central part of the ranges between Tomkinson Creek northward to the headwaters of Hunter Creek. A dolerite sill intrudes the upper beds of the unit between the Stuart Highway and the southern part of Lake Woods, and Ivanac (1954) reports basalt and porphyry in the Tennant Creek Sheet area.

Cross-bedding, ripple-marks, primary current lineation, halite casts, mud clasts, clay blebs, and mud cracks occur in the clastic sediments; some of the carbonate rocks and chert contain algal stromatolites. The sandstones are cemented by siliceous or argillaceous material, and are tough and extremely hard. Surfaces of sandstone outcrops have a siliceous skin; in addition, in much of the sandstone overgrowths of quartz fill the interstices between quartz grains, giving the rock a recrystallized appearance; they are not, however, true quartzites. Few very friable sandstones are known in the sequence.

The Tomkinson Creek Beds are extensively folded and faulted, but the intensity decreases from south to north, and from older to younger beds. The major faults and the fold axes strike predominantly north, parallel to the trend of the Ashburton Range, although there are some exceptions southwest of Muckety homestead and southeast of Helen Springs homestead. The folding and faulting appear to be genetically related; the unit shows no signs of regional metamorphism, which implies that the thick sandstones did not yield significantly by plastic flow, but rather by block faulting. The major faults, which appear to be high-angle ones, are accompanied by a zone about half a kilometre wide of brecciation, jointing, and slickensiding, where the strata are dragged into steep and locally overturned attitudes; they are accompanied by extensive silicification of the sandstone.

Smith (1972) considers the Tomkinson Creek Beds to be coeval with the Hatches Creek Group in the Davenport Ranges, 80 km south of Tennant Creek, and places both in the ?Lower Proterozoic. Some workers believe the age of both units to be Carpentarian because of isotopic ages of granites intruding the Hatches Creek Group, but Smith questions the validity of the age measurements.

PALAEOZOIC

Lower Cambrian

Three suites of Lower Cambrian volcanic rocks crop out in the region: the Antrim Plateau Volcanics in the west, northwest, and north; the Nutwood Downs Volcanics in the east; and the Helen Springs Volcanics about the Ashburton Ranges in the southeast.

The *Antrim Plateau Volcanics* crop out in a broad belt trending north-northwest from near Hooker Creek to the valley of the Flora River; discontinuous outcrops continue to the northern part of the Daly Basin near the headwaters of the

Reynolds and Adelaide Rivers. Randal (1963) regarded identical rocks cropping out on the eastern side of the Daly Basin near Katherine and along the Roper Valley as being continuous beneath younger sediments with the main mass of the Volcanics. This correlation was followed by Dunn (1963a), and Randal et al. (1966) reported supporting evidence for it from waterbore and scouthole drilling west and southwest of Larrimah.

Tholeiitic basalt is the dominant rock type, but trachyte and other lavas are known. The sequence contains considerable amounts of sandstone, limestone, chert, and siltstone (Randal et al., 1966). The lavas are usually compact and visibly crystallized as fine to coarse-grained rocks, but the tops and bottoms of flows are aphanitic and vesicular or amygdaloidal. Many vesicles are filled with banded agate, smoky and amethystine quartz or prehnite, and zeolite minerals, but many are open and are interconnected. The basalt is well jointed, the spacing and tightness of the joints being widely variable. Deep weathering is common, particularly where tuffaceous interbeds crop out in stream beds and banks.

Although Traves (1955) recognized agglomerates and tuffs in the Volcanics, the presence of sandstone, limestone, and chert beds within the sequence has been noted only recently. Barclay & Hays (1965) report sandstone in drill cuttings from Wave Hill and in outcrops near Pigeon Hole homestead; water bores near the Western Australian border penetrated sandstone (J. Shields, NTA, pers. comm.); and photo-interpretation of the Delamere and Victoria River Downs Sheet areas (Perry, 1966) suggested that sandstone is interbedded with the Volcanics, and this was confirmed by field mapping (Randal & Brown, 1967).

Two main types of sandstone have been recognized in outcrop. The first is a friable medium-grained rock, with large-scale crossbeds in sets commonly 3 m or more thick. Many outcrops are elongated west-northwest and the crossbeds dip west or northwest. This sandstone was apparently deposited as elongated sand ridges under aeolian conditions and subsequently covered by lava flows. It is strongly indurated for several centimetres below the basalt and its surface has shallow elongated ridges and furrows presumably caused by viscous drag of the lava moving across the surface. The second type of sandstone is fine to medium-grained, and is either flatly laminated, with current lineations on the bedding surfaces, or ripple-bedded. It is commonly interbedded with siltstone or chert. Both sandstones are composed mainly of quartz, rock fragments, and feldspars. The rock fragments are siltstone, basalt, and glass, and the feldspars are microcline and orthoclase. Quartz-mullite(?) intergrowths occur in the interstices between the grains of the indurated sandstone. The cement is usually quartz, but calcite is known, and at Pandanus Spring, southwest of Willeroo homestead, a barite or celestite cement gives the rock a pseudo-fontainebleau appearance. In the cross-bedded sandstone the grains are well sorted and rounded, but in the others the grain-size is more variable.

Randal & Brown describe an extensive chert bed about the Armstrong River and Illawarra Creek, where erosion clearly reveals the contacts of the chert with basalt above and below; they describe other chert beds, some associated with limestone, which occur west of Top Springs, south and southwest of Camfield homestead, and south and east of Wave Hill homestead. Three separate chert beds, separated by basalt flows, form benches in the hills south of Moolooloo homestead. The chert replaced limestone and calcareous siltstone. Thin sections of chert show textures similar to those of the limestone and in outcrop bedding laminations in limestone can be traced laterally into massive chert. Ghosts of intraclasts and of shell fragments have been recognized. The limestone is a laminated microcrystalline rock with some sand, silt, and clay impurities. They appear to have been deposited as laminated carbonate muds and subsequently recrystallized. Some of the chert may be silicified tuff or silicified tuffaceous siltstone; fragments of basaltic glass shards are common in thin section, and some cherts, especially near Camfield homestead, are vuggy and brecciated and have geodes containing copper-stained and amethystine quartz. The chert and limestone beds are fractured and jointed and have a wide range of thicknesses.

The Antrim Plateau Volcanics are mainly subaerial flows, but some flows solidified in shallow water, in either intertidal marine or lacustrine situations.

An angular unconformity separates the Precambrian rocks and the Antrim Plateau Volcanics. The old land surface had considerable relief; Traves (1955) states that the Volcanics occur in old valleys, some 200 ft (60 m) deep, now exposed along the Victoria River between Coolibah and Willeroo. The Volcanics are overlain with a slight unconformity by Middle Cambrian carbonate rocks, and are regarded as Lower Cambrian.

The thickness of the Antrim Plateau Volcanics has a wide range. They are thickest in the central west near Mooloolоо homestead, where 60 m are exposed and a further 590 ft (177 m) intersected by Shoeing Tool Replacement Bore. The sequence becomes thinner both north and south: 200 ft (60 m) in the Fergusson River Sheet area (Randal, 1962); about 460 ft (140 m) in the eastern part of Wave Hill station (Randal & Brown, op. cit.); 100 ft (80 m) in the Katherine area (Randal, 1963); and 200 ft (60 m) in the Hodgson Downs and Urapunga Sheet areas (Dunn, 1963a, b).

In the northeastern part of the region the Antrim Plateau Volcanics consist of amygdaloidal basalt, tuffaceous sandstone, and red feldspathic sandstone.

The *Nutwood Downs Volcanics* crop out in the valley of the Hodgson River in the northeast. Bore data from Nutwood Downs station suggest they extend southward into the Tanumbirini Sheet area. The unit consists of tholeiitic basalt, andesite, agglomerate, tuff, and flaggy feldspathic sandstone. The basalt contains numerous amygdales filled with quartz, jasper, and chalcedony; it is fractured and jointed. Dunn (1963) estimates the thickness of the unit at 400 ft (120 m). The Nutwood Downs Volcanics are conformably underlain by the Bukalara Sandstone and disconformably overlain by fossiliferous Middle Cambrian carbonate rocks.

The Antrim Plateau Volcanics and the Nutwood Downs Volcanics are petrographically similar and occupy a similar stratigraphic position—disconformable beneath lower Middle Cambrian carbonate rocks. They are believed to belong to the same Lower Cambrian volcanic suite which covers large parts of the Northern Territory. West of the Hodgson River the Nutwood Downs Volcanics disappear beneath Lower Cretaceous rocks. Isolated outcrops occur in the eastern tributaries of the Strangways River, 96 km east of BMR Scouthole L2, near Western Creek homestead; in this hole, amygdaloidal basalt was encountered below fossiliferous Middle Cambrian limestone at about 165 ft (50 m). The scouthole is itself about 96 km east of the nearest outcrop of the main western mass of the Antrim Plateau Volcanics, but between the scouthole and the outcrops, bores on the Dry River Stock Route and the Willeroo/Top Springs Road intersected basalt at depth. Also the most northerly outcrops of the Nutwood Downs Volcanics in the Strangways

River watershed are a mere 26 km from outcrops of the eastern mass of the Antrim Plateau Volcanics in the Roper Valley. Hence the two units appear to be continuous or nearly so in the east, and appear to extend in the subsurface to join with the main mass of volcanics in the west.

The Lower Cambrian *Bukalara Sandstone* conformably underlies the Nutwood Downs Volcanics in the Hodgson River valley and its environs. The sandstone is a medium to coarse-grained well sorted quartz sandstone, cross-bedded and well jointed. The outcrops in the Hodgson River valley have been equated by Dunn (1963a) with other outcrops farther east because of their lithological similarity and the unconformable relationship with the underlying Roper Group. The formation is 60 m thick. Paine (1963) considers that sandstone intersected at 70 ft (21 m) in N.A. Bore along the Hodgson River in the Tanumbirini Sheet area is an Upper Proterozoic (Adelaidean) unit, but it could also be part of the Bukalara Sandstone.

The *Helen Springs Volcanics* crop out on the eastern and western flanks of the Ashburton Range and in valleys within it. They form mesas capped by thick laterite or lateritized rocks and grassy plains of black or brown clayey soil in the lower country around them. A basal sandstone forms well developed strike ridges in places. The Volcanics consist of massive coarse-grained tholeiitic basalt, vesicular aphanitic basalt near and at the base, silicified basalt, and sandstone.

The basalts consist essentially of plagioclase and augite; olivine and its pseudomorphs are absent. Deep weathering and lateritization are common: the plagioclase is albitized and sericitized and the augite is partly or completely altered to chlorite or pale green fibrous amphibole. In most of the silicified basalts the original igneous textures are still visible only in thin section; silicification is most common in the fine-grained rocks. Interbedded chert crops out on the western side of the Ashburton Range. In the pallid zone of the laterite the basalt is kaolinized but the original textures can be recognized; they are identifiable in most of the mottled zone, but are obliterated in the ferruginous zone.

Sedimentary rocks conformably underlie the basalt at several localities and have been mapped as part of the volcanic sequence. The predominant rock is a laminated semi-friable sandstone with large crossbeds in sets up to 6 m thick. The rock is fine to medium-grained, but within individual laminae the sorting is good. The grains consist of quartz, quartzite, chert, and siltstone. The cement is mainly siliceous. Beds of sedimentary breccia occur in the cross-bedded sandstone; the clasts are quartzite and siltstone and the matrix sandstone. The sandstone directly below the basalt is indurated and in thin sections the sandstone matrix is seen to contain intergrowths of quartz and sillimanite or mullite. The upper surface of the sandstone has shallow ridges and furrows apparently caused by viscous drag of the lava moving over the surface. Both these features have been noted in the sandstones within the Antrim Plateau Volcanics in the western part of the region. Like them, the sandstones under the Helen Springs Volcanics have been interpreted as aeolian dune deposits.

The maximum thickness of the Helen Springs Volcanics is not known. At Muckety homestead a bore penetrated 120 ft (36 m) of basalt without encountering the underlying rocks. A thickness of 18 m is exposed in the mesas near Helen Springs homestead; the surface rock at several nearby bores is basalt, but the bores have not been lithologically logged. The basal sandstone varies considerably in thickness, from 15 cm to 12 m.

Noakes & Traves (1954) regarded the Helen Springs Volcanics as Lower Cambrian and equated them with the Antrim Plateau Volcanics. Subsequent mapping (Randal et al., 1966) proved the presence of the Volcanics on the western flanks of the Ashburton Range, where they apparently underlie the Middle Cambrian Gum Ridge Formation. Also the Volcanics have been reported in the Hidden Valley Bore 65 km west-southwest of Daly Waters, and are suspected in Burge Bore near the southern part of Lake Woods. It is possible that the two volcanic units are continuous or nearly so beneath the younger Cambrian rocks of the Wiso Basin. Similarly the Helen Springs Volcanics and the Nutwood Downs Volcanics may be linked by discontinuous occurrences beneath the younger deposits in the Beetaloo and Tanumbirini Sheet areas.

Middle Cambrian

The *Montejinni Limestone* crops out on the western side of the central and northern parts of the Wiso Basin. It occurs in a long and narrow meridional belt from the headwaters of the Camfield River in the south to east of Delamere homestead in the north. Isolated outcrops occur in the valley of Cattle Creek northeast of Hooker Creek Settlement. The formation borders the western margin of the Main Plateau: in the central part of the meridional belt it forms a rugged dissected terrace flanking the plateau; in the southern part the terrace merges imperceptibly into the plateau. The unit also forms isolated mesas some kilometres west of the terrace and scarp of the Main Plateau, and west of Birrimba homestead crops out as boulders in grassy plains and woodlands. In the northwest the Montejinni Limestone dips gently eastward beneath the Lower Cretaceous rocks of the Plateau, and limestones reported at depth in some water bores on the Plateau are referred to it, or to its northern and northeastern equivalent, the Tindall Limestone. To the south it passes beneath the sand cover and reappears in the central part of the Wiso Basin, where it underlies the upper part of the Merrina Beds, and is equivalent to the lower part of that unit (Milligan et al., 1966). These aspects are discussed later.

The Montejinni Limestone consists of limestone, dolomite, dolomitic limestone, silty carbonate rocks, and calcareous mudstone or siltstone. In places it contains abundant chert nodules and stringers. Milligan et al. (op. cit.) record thin to medium-bedded quartzose microcrystalline limestone, dolomitic siltstone, and crystalline limestone northeast of Hooker Creek. Between Cattle Creek and Delamere homesteads, Randal & Brown (1967) recognized a threefold division of the formation in both outcrop and in water bore and scouthole cuttings—an upper and a lower limestone unit separated by a middle mudstone unit. A composite section is presented below:

		Top
Unit 3	30 m	Grey to brownish limestone with stromatolites near the base, overlain by dark grey dolomitic limestone and grey crystalline limestone with *Redlichia, Biconulites,* and *Girvanella.* Contains small patches of dolomite and is partly silicified. Minor chert nodules. Medium, thick, and massive bedding.
Unit 2	18 m	Red to buff calcareous siltstone, red-brown and yellow-buff calcareous mudstone, silty carbonates. Contains a persistent band of silicified rocks at its base. Thin-bedded and laminated. The unit is poorly exposed; it frequently produces a red-brown soil with rubble of red travertine.

Unit 1	3 m	Stromatolitic limestone, dolomitic limestone, fetid black and grey crystalline limestone; chert nodules and stringers. Thick-bedded.
	18 m	Thin-bedded, light grey crystalline limestone.
	12 m	Thick-bedded, dark grey crystalline limestone with abundant chert nodules, containing *Redlichia*.

The age and stratigraphic relationships of the formation are discussed on pages 23 to 24.

The *Tindall Limestone* is the basal Middle Cambrian unit of the Daly Basin in the northern part of the region. It is continuous from Mathison Creek in the west around the northern part of the Daly Basin to the valley of the Roper River and its southern tributaries in the east. However, near Dorisvale homestead it is overlapped by younger units which rest directly on the basement rocks; it also crops out in the valley of the Dry River near its confluence with the King River. Bore data suggest that the formation extends subsurface to near Newcastle Waters and the Daly Waters/Borroloola Road in the south. Outcrops of fossiliferous limestone in the Hodgson Downs Sheet area are referred to the Tindall Limestone. The formation crops out as scattered blocks in grassy plains or woodlands, as low karst outcrops, or as pavements and banks in watercourses.

No sections have been measured in outcrops of the Tindall Limestone; Randal & Brown (1967, appendix 1), using cuttings, give detailed descriptions of parts of the unit intersected in scoutholes and water bores. The formation consists of light brown, grey-brown, buff, and yellowish calcilutite, fine crystalline limestone, dolomitic limestone, and dolomite. It contains chert nodules and stringers, but these are not as prevalent as in the Montejinni Limestone. Two-tone grey and yellow or brown limestone occurs in several outcrops and in the drill holes. In many outcrops the lighter-coloured material (consisting of coarser recrystallized calcite) has been extensively dissolved, producing a honeycombed rock with high storage capacity, but it is not known if this phenomenon occurs subsurface. The limestone is fossiliferous: *Biconulites,* ptychoparioid trilobites, phosphatic brachiopods, obolidae, and cystid plates have been found in drill cuttings; and *Biconulites,* phosphatic brachiopods, obolidae, *Girvanella, Helcionella, Hyolithes, Redlichia,* and sponge spicules have been found in outcrop.

The Tindall Limestone disconformably overlies the Lower Cambrian volcanics and in places appears to overlap them to rest unconformably on the Precambrian rocks. The age and the relationship of the unit to other Middle Cambrian rocks is discussed on pages 23 to 24.

The Tindall Limestone is at least 30 m thick in the northern part of the Main Plateau, but farther north in the Daly Basin the thickness may be 150 m or more.

The *Gum Ridge Formation* (Öpik, 1956) crops out along the eastern and western flanks of the Ashburton Range, in valleys within the Range, and in the eastern and western parts of the Tennant Creek 1:250 000 Sheet area. Thus it is a marginal unit of both the Georgina Basin to the east and the Wiso Basin to the west. The formation usually occurs as low rubble-covered mounds and rises on which dip measurements are impossible.

The formation consists of impure sandy limestone, chert, siliceous shale, and sandstone in the Tennant Creek area; Randal et al. (1966) extended the unit to include chert, siliceous shale, altered carbonate rocks, and sandstone cropping out around Banka Banka homestead and on the flanks of the Ashburton Range, and dolomite, dolomitic limestone, limestone, and chert occurring in water bores east of the Range.

Like other Cambrian units on the Barkly Tableland to the east, the Gum Ridge Formation has been extensively altered and lateritized (Randal, 1966a and b). Most of the surface exposures now consist of fossiliferous chert, silicified shale, and sandstone and altered carbonate rocks, commonly covered by a brecciated and recemented mixture of chert and silicified sandstone or siltstone, identical with that formed on the Wonarah Beds to the east (Randal, 1966a and b). How deeply this silicification affected the rocks is unknown, but it is probably only shallow.

The Gum Ridge Formation is richly fossiliferous: Öpik (1956) and Gatehouse (*in* Randal et al., 1966) report *Xystridura, Peronopsis, Pagetia, Chancelloria, Eiffelia, Biconulites, Billingsella,* and *Redlichia* in the Tennant Creek area, and farther north *Xystridura, Redlichia, Billingsella, Biconulites, Wimanella,* ptychoparioids, and inarticulate brachiopods. Most of the determinations were at species level and clearly indicate an early Middle Cambrian age for the formation.

The thickness of the Gum Ridge Formation is unknown. In the Tennant Creek area 14 m of rocks are exposed; the upper part has been removed by erosion. If all the rocks penetrated in No. 12 South Barkly Stock Route Bore are referable to the formation then its thickness exceeds 50 m.

In the Helen Springs Sheet area there is a strong angular discordance between the Gum Ridge Formation and the Tomkinson Creek Beds, and a disconformity between it and the Helen Springs Volcanics. Relationships between the formation and the older rocks in the Tennant Creek Sheet area also indicate a time break between the two. The relationship to other Middle Cambrian units is discussed later.

The *Anthony Lagoon Beds* crop out in the eastern part of the Helen Springs Sheet area and the southern part of the Beetaloo Sheet area. The unit is known subsurface in the Beetaloo Sheet area and may extend northward into the Tanumbirini Sheet area. It is the most widespread unit in the central and western Barkly Tableland portion of the Georgina Basin.

Surface exposures consist of limestone, dolomitic limestone, dolomite, sandstone, chert, siltstone, and silicified and leached carbonate rocks. Scouthole and water bore drilling indicates considerable amounts of calcareous and dolomitic siltstone and sandstone. Chert is present in both outcrop and the subsurface but is not common. The texture and nature of the carbonate rocks are variable: some dolomite and limestone has a fine pelletal texture with the pore spaces between pellets incompletely filled, but other parts are uniformly microcrystalline to finely crystalline and compact. Both contain zones of abundant solution vugs. Some limestone contains fine calcite rhombs set in a calcilutite matrix. The sandstone in the Anthony Lagoon Beds is fine to medium-grained, flaggy, and ripple-marked; surface silicification is common, but many bore cuttings are friable. Much of the chert contains ghosts of dolomite rhombs and is clearly the replacement product of original carbonate rock.

The maximum known thickness of the Anthony Lagoon Beds in the western Barkly Tableland is 258 ft (80 m) in No. 6 Barkly Stock Route Bore; however, to the east it appears to be over 1000 ft (300 m) (Randal, 1966b). The age and relationships are discussed later.

The *Merrina Beds* occur in the southwestern and central part of the region, and form the most widespread unit of the central and southern Wiso Basin, but outcrops are few. It crops out as low hills or rubble-covered rises in the scrub-covered sand plain west of the Stuart Highway and the Ashburton Range. Much information about the sequence came from a series of scoutholes between Tennant Creek and Hooker Creek Settlement (Milligan et al., 1966). The Beds may extend subsurface as far north as the Murranji Stock Route (Randal & Brown, 1967).

The lithology of the Merrina Beds is variable: the sequence is dolomite at the base, dolomitic siltstone and claystone and fine-grained sandstone with interbedded dolomite, and medium and coarse-grained sandstone at the top. In the northern part of the Wiso Basin the rocks consist of dolomite, dolomitic limestone, chert, silicified carbonate rocks, and sandstone. The dolomites are microcrystalline, but recrystallization has produced some coarser rocks. The sandstones are porous, fine-grained, and mostly well sorted. Bedding varies from thinly laminated to massive.

Milligan et al. (1966) describe the following composite section from the outcrop and subsurface data:

	Top
330 ft (100 m)	White and grey sandstone (leached and decemented rocks). Red-brown quartz sandstone, partly dolomitic, with interbedded brown siltstone and dolomite. Claystone.
250 ft (75 m)	Interbedded dark brown siltstone and claystone, partly dolomitic, and thinly bedded microcrystalline dolomite. Stromatolites, *Lingula, Biconulites, Girvanella,* and fragments of trilobites and echinoderms.
190 ft (60 m)	Brown-grey to dark grey dolomite, partly argillaceous and partly calcareous. Chert fragments. *Biconulites* and trilobite fragments, *Acrotreta,* and *Acrothele.*

The age of the unit and its relationship to other Middle Cambrian rocks are discussed later.

Cambrian/Ordovician

The *Jinduckin Formation* crops out in the Daly Basin in the northern part of the region. It forms isolated mesas and rubble-covered hills, some capped by Lower Cretaceous rocks, and occurs on the northwestern slopes of the Main Plateau. Siltstone beds overlying carbonates in Scoutholes L1, L2, L3, and in the Maryfield homestead bore, all near Larrimah, are similar to those in the formation, but their equivalence has not been proved.

The Jinduckin Formation consists of interbedded sandstone, siltstone, dolomite, and dolomitic limestone. It is thin to medium-bedded, flaggy, and in part silicified. It contains thin chert bands and nodules. Outcrops of sandstone and siltstone are characteristically red, chocolate, or buff. The carbonate rocks are commonly pinkish grey on the weathered surface; they are microcrystalline to finely crystalline and are stromatolitic. The sandstones are well sorted and are fine to medium-grained; they are cross-bedded and cross-laminated. Halite casts occur in both the sandstone and the siltstone. Local developments of dolomite, dolomitic limestone, and limestone have been mapped as the *Manbulloo Limestone Member.*

The Jinduckin Formation appears to overlie conformably the early Middle Cambrian Tindall Limestone. No definite contacts between the two have been seen in outcrop, but in many places the two formations have a concordant strike and dip. Furthermore, in scouthole K1 the contact between the two seems gradational (Randal & Brown, 1967). Randal (1962, 1963) considered the contact conformable and regarded the Jinduckin Formation as Middle Cambrian, although no diagnostic fossils were found. Subsequently trilobites and brachiopods of Lower Ordovician age (Öpik, 1968) were found in rocks near the top of the formation near Claravale homestead. It is not known if the formation represents continuous, but slow, sedimentation from early Middle Cambrian to Lower Ordovician time, or if there are breaks in the sequence.

Randal & Brown (1967) report at least 455 ft (137 m) of the formation in the southern foot of the Daly Basin.

Sediments cropping out in the southwestern portion of the region are shown on the map as undifferentiated lower Palaeozoic rocks after Milligan et al. (1966). The rocks are grey dololutite with chert nodules, red sandy calcilutite, and fine-grained argillaceous quartz sandstone and siltstone. The sandstone and siltstone contain halite casts. The rocks are unfossiliferous, and are overlain by rocks equated to the Devonian Dulcie Sandstone by Milligan et al., who regard the older rocks as possible equivalents of either the Middle Cambrian Merrina Beds or the Ordovician Hanson River Beds which crop out to the south of this region.

Ordovician

The *Oolloo Limestone* is the uppermost Palaeozoic unit in the Daly Basin. It conformably overlies the Jinduckin Formation and consists of limestone and dolomite, silicified in places, and minor chert beds. It is about 200 ft (60 m) thick (Randal, 1962).

Devonian

Medium to thick-bedded argillaceous sandstone and clean friable quartz sandstone crop out in the southwestern part of the region. The rocks are referred by Milligan et al. (1966) to the *Dulcie Sandstone* of the Georgina Basin (Smith, 1972). The unit is 18 m thick.

Relationships of the Cambrian units

The Montejinni Limestone, the Tindall Limestone, the Gum Ridge Formation, and the lower parts of the Merrina Beds, all contain shelly fossils which indicate generally an early Middle Cambrian age. Milligan et al. (1966) report that the upper sandstone and siltstone unit of the Merrina Beds conformably overlies the Montejinni Limestone and they equate the limestone with the lower part of the Merrina Beds. Randal & Brown (1967) equate the upper part at least of the Montejinni Limestone with part of the Tindall Limestone because of lithological similarity and by means of subsurface data provided by water bores and scoutholes. Bore data suggest that the lower parts of the Merrina Beds may occur subsurface as far north as the Murranji Stock Route and that the Tindall Limestone may extend subsurface as far south as Newcastle Waters and eastward across the Tanumbirini Sheet area. The fossil assemblages in the Tindall Limestone and the Gum Ridge Formation as listed by Öpik (1956) clearly establish the time equivalence of these two formations. Also limestone intersected by bores north of Daly Waters, which is probably Tindall Limestone, is lithologically very similar to fossiliferous limestone, probably Gum Ridge Formation, in South Barkly Stock Route No. 12 Bore. Similarly the fossil assemblages in the lower Merrina Beds and in the Gum Ridge Formation on the western flanks of the Ashburton Range, and the spatial distribution of the two units, suggest that they are continuous in part. Hence the fossiliferous early Middle Cambrian units in the Daly, Wiso, and Georgina Basins in this region appear to be the result of contemporaneous or nearly contemporaneous deposition of mainly carbonate rocks over a very large area; the variations in the rock types were due to the amount of terrigenous material available, minor changes in environment, and the time and degree of dolomitization and silicification of the original carbonate muds.

Because of the lack of diagnostic fossils the exact stratigraphic relationship of the Anthony Lagoon Beds with other Cambrian rocks is indefinite. Randal (1966b) lists a number of localities from which unidentifiable fossils have been discovered and states: '. . . since the Anthony Lagoon Beds appear to form part of the widespread carbonate rocks of the Barkly Tableland which in adjoining areas contain early Middle Cambrian . . . this unit is provisionally assigned to the Middle Cambrian.' Randal & Nichols (1963) believed that the Anthony Lagoon Beds may be in part equivalent to the Top Springs* Limestone, which crops out on the northern margin of the Barkly Tableland some 48 km east of this region. This limestone contains fossils which suggest an upper Lower Cambrian or lower Middle Cambrian age, and it may be an equivalent of the Tindall Limestone, which it markedly resembles in outcrop.

Brown has been studying the palaeogeography and environment of the Cambrian rocks of the northern part of the Northern Territory from outcrop and subsurface data and believes (1968, and pers. comm.) that two main units can be recognized. The older is the mainly carbonate early Middle Cambrian rocks containing shelly fossils as represented by the Tindall Limestone and its equivalents as discussed above, the Top Springs Limestone, and other mainly carbonate rocks intersected in boreholes to the east of this region. The younger is a dolomite-sandstone-siltstone sequence characteristically red-brown, buff, or chocolate-coloured in outcrop and subsurface. This unit is represented in the Daly Basin by the lower part of the Jinduckin Formation, in the Wiso Basin by the upper part of the Merrina Beds, and in the western Georgina Basin by rocks in the upper part of the Anthony Lagoon Beds. Brown suggests the age of this unit is early Middle Cambrian to (?) Upper Cambrian and that most of the surface outcrops of the Anthony Lagoon Beds are part of it. Although outcrops of limestone similar to Brown's older unit occur within the outcrop area of the Anthony Lagoon Beds, he cites considerable evidence to support his concept in general. The concept is extremely important hydrogeologically and should be investigated by further scout-hole or stratigraphic drilling: in the upper unit, because of its interbedded and varied rock types, potential aquifers are more likely to be controlled stratigra-

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* Not to be confused with Top Springs in the Victoria River District in the west of this region.

phically than in the lower mainly carbonate unit, where the occurrence of aquifers is more likely to be controlled by the incidence of cavities and fissures.

MESOZOIC

Unnamed Mesozoic sediments occur in broad valleys eroded below the summit plain of the Ashburton Range. They have been partly eroded and hence sometimes occur as cappings on low mesas. The rocks are boulder conglomerate, sandstone. pebbly sandstone, and siltstone. The outcrops are widely scattered and no correlation between sections has been established; Randal et al. (1966) estimate that the rocks are 80 ft (24 m) thick. Plant impressions have been determined as Jurassic or Lower Cretaceous. The sediments are tentatively correlated with the lower non-marine part of the Mullaman Beds, which are exposed to the northeast.

Flat-lying sediments of the Lower Cretaceous *Mullaman Beds* crop out over much of the northwestern, northern, and eastern parts of the region. Outcrop is especially good in mesas and escarpments on the dissected margins of the Main Plateau; within the Plateau the unit occurs as low rocky knolls or as scattered rubble in the sand and soil, but considerable information has been obtained from scoutholes and water bores (Randal & Brown, 1967; Randal et al., 1966; Brown, BMR file notes). Skwarko (1966, 1967) examined the Mullaman Beds in the region and the following comments are based on his results, supplemented by the mapping and subsurface data compiled by Randal & Brown.

The lowermost unit is a non-marine saccharoidal sandstone with, in places, basal beds of grit, and pebble and boulder conglomerate. This unit is equated with Skwarko's Unit A of his Inland Belt Suite and with the Lees Sandstone named in the Mount Isa area by Öpik, Carter, & Noakes (1961). The age of the unit is ?Neocomian-Aptian. It is overlain by marine claystone and siltstone with sandy interbeds of Aptian age which Skwarko (1967) refers to Unit 6 of his Coastal Belt Suite. Unit 6 is overlain by an Aptian marine unit of yellow, brown, or red, medium-grained micaceous quartz sandstone. Skwarko refers to this as Unit 6a; it occurs in the Coastal Belt Suite, but because of poor exposures he previously included its outcrops within Unit 6. The uppermost unit within the Mulligan Beds is a marine siltstone and claystone of Albian age; it disconformably overlies the Aptian rocks and in places overlaps them. Skwarko (1967) refers to this subdivision as the Polland Shale, which occurs in the Mount Isa area (Öpik et al., 1961) and is the same as Unit C of his Inland Belt Suite. In addition, Skwarko (1966) records that in places Unit A and Unit C are separated by a transitional sequence which in the Inland Belt Suite he has named Unit B. This unit occurs in the northern and northeastern part of the region, but has been recognized within the Main Plateau area only from scoutholes in the northern part of the Barkly Tableland. The thickness of the units varies considerably.

The individual units are not shown on the geological map; the outcrop width of the divisions along the margins of the Plateau is too narrow to show at 1:1 000 000 scale, and on the Plateau itself too few outcrops have been visited to delineate the boundaries even approximately, but general observations are possible. Most of the Lower Cretaceous outcrops in the central part of the Daly Waters Sheet area are considered to be equivalent to Polland Shale—Unit C—and those in the central and northern part of the Larrimah Sheet area to the Lees Sandstone —Unit A. Units 6 and 6a may crop out along the boundary between these two Sheet areas and north of Hidden Valley homestead.

The Mullaman Beds unconformably overlie the Precambrian rocks, the Lower Cambrian volcanic sequences, and the lower Palaeozoic rocks of the Wiso, Georgina, and Daly Basins. The present topography of the surface on which the Cretaceous sequence was deposited is illustrated by structure contours in Figure 2. This surface is important hydrogeologically and is referred to in a later chapter.

Skwarko reports at least 165 ft (50 m) of Lower Cretaceous rocks in the western escarpment of the Main Plateau. The maximum known thickness was encountered in water bore CCE on the Borroloola Road, where 475 ft (143 m) of Units C, 6, and 6a were encountered; water bore CCD 16 km to the west encountered about 150 ft (45 m) of Unit A beneath Unit 6. Figure 3 shows the present thickness of the Mullaman Beds. Because the top of the Mullaman Beds is an erosional surface the isopachs do not show the depositional thickness, but the map is important hydrogeologically; it indicates the depth of overburden covering the Middle Cambrian rocks, which are more reliable water producers than the Lower Cretaceous sequence. This is discussed further in a later chapter.

CAINOZOIC

Most of the Palaeozoic and Mesozoic rocks have been extensively altered by Tertiary lateritization. All three zones of the classical laterite profile—ferruginous, mottled, pallid—occur, but are not everywhere present. Some material in the ferruginous zone shows apparent bedding and size sorting of ironstone pisolites and may be recemented detrital laterite. Much of the northern and eastern part of the Main Plateau is covered by a gravel of ironstone pisolites. The laterite cannot be precisely dated: it overlies Lower Cretaceous rocks, and appears to underlie Tertiary limestones in the northern Wiso Basin (Randal & Brown, 1967) and in the northwestern Georgina Basin (Randal et al., 1966). Lateritic gravels are reputedly 24 m thick in some water bores.

Tertiary limestone occurs in widely scattered parts of the region, mainly within the plateau but also along its western margin. The units are: an unnamed limestone and clay sequence in the Wiso Basin west of Tennant Creek; the *Brunette Limestone,* in the central and western parts of the Barkly Tableland; the *Camfield Beds,* on the western margin of the Main Plateau between Camfield and Cattle Creek homesteads; the *Birdum Creek Beds,* between Larrimah and the Dry River; and the *Golliger Beds,* which are small isolated outcrops in the Tanumbirini Sheet area. Only the unnamed unit in the southern part of the region is being exploited for groundwater. The limestones may have some bearing on the amount of recharge and quality of the water entering underlying rocks (Randal, 1967); this is discussed later. Fossils from the Brunette Limestone, the Birdum Creek Beds, and the Camfield Beds indicate an early Miocene age.

Superficial unconsolidated deposits are widespread: they consist of sand, sandy soil, and pisolitic gravels, travertine, black, grey, and brown pedocalcic soils, and alluvium.

The most extensive sandy stretches occur in the desert area of the Main Plateau south of the Murranji Stock Route and west of the Ashburton Range. North of the stock route the sand contains a great deal of pisolitic ferruginous gravel, and low rises composed almost entirely of pisolitic gravel are common not only there, but also on the Beetaloo and Tanumbirini Sheet areas in the east. On the eastern flank of the Ashburton Range, sand covers a piedmont desert which slopes

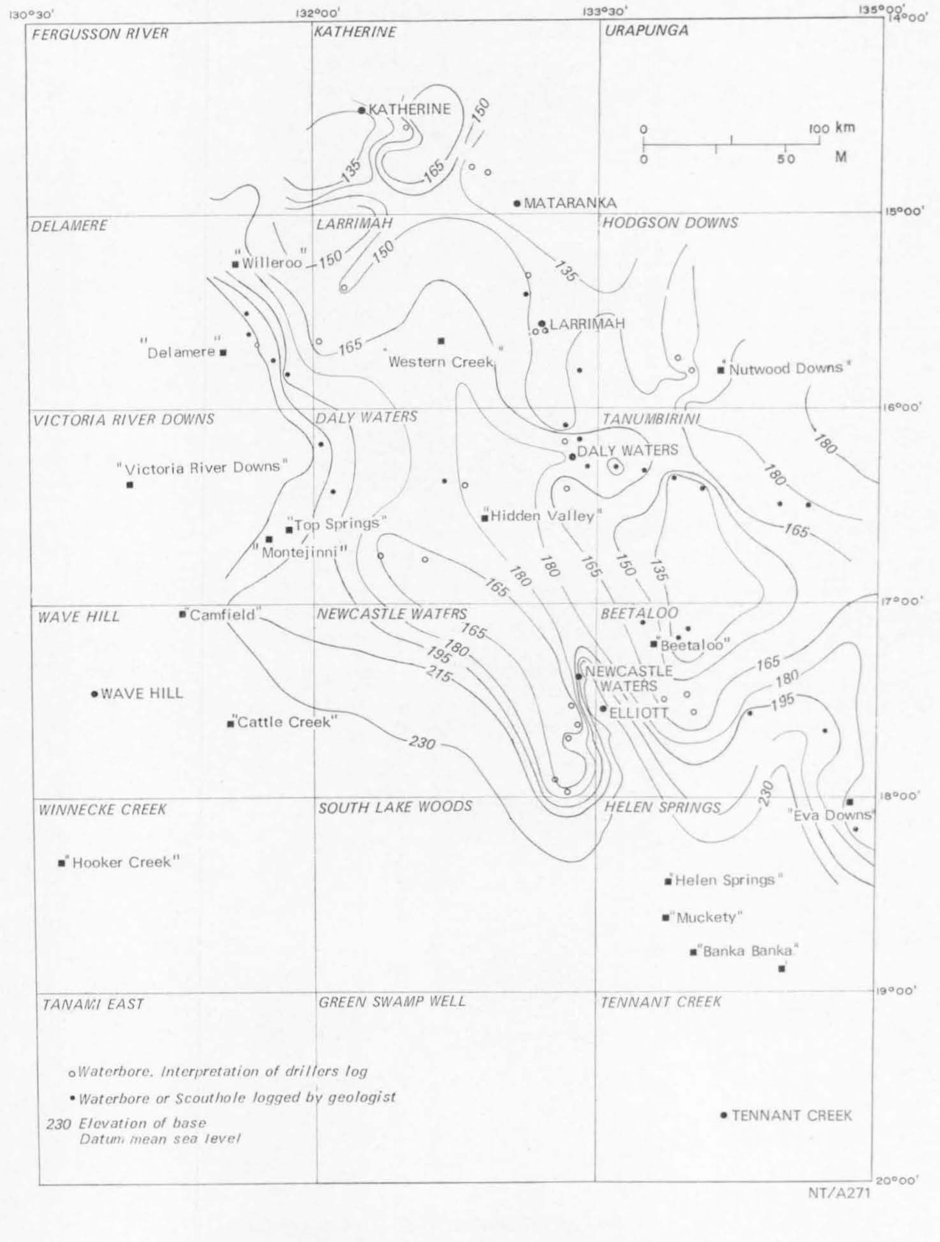

Fig. 2. Structure contours on unconformity at base of Mullaman Beds.

down gradually from the range and terminates abruptly against the black soils and alluvia of the Barkly Tableland. The sand is mainly colluvial, but probably contains some material transported by wind and streams. The sand has probably been derived from the Tomkinson Creek Beds, the upper part of the Merrina Beds, and the basal unit of the Mullaman Beds.

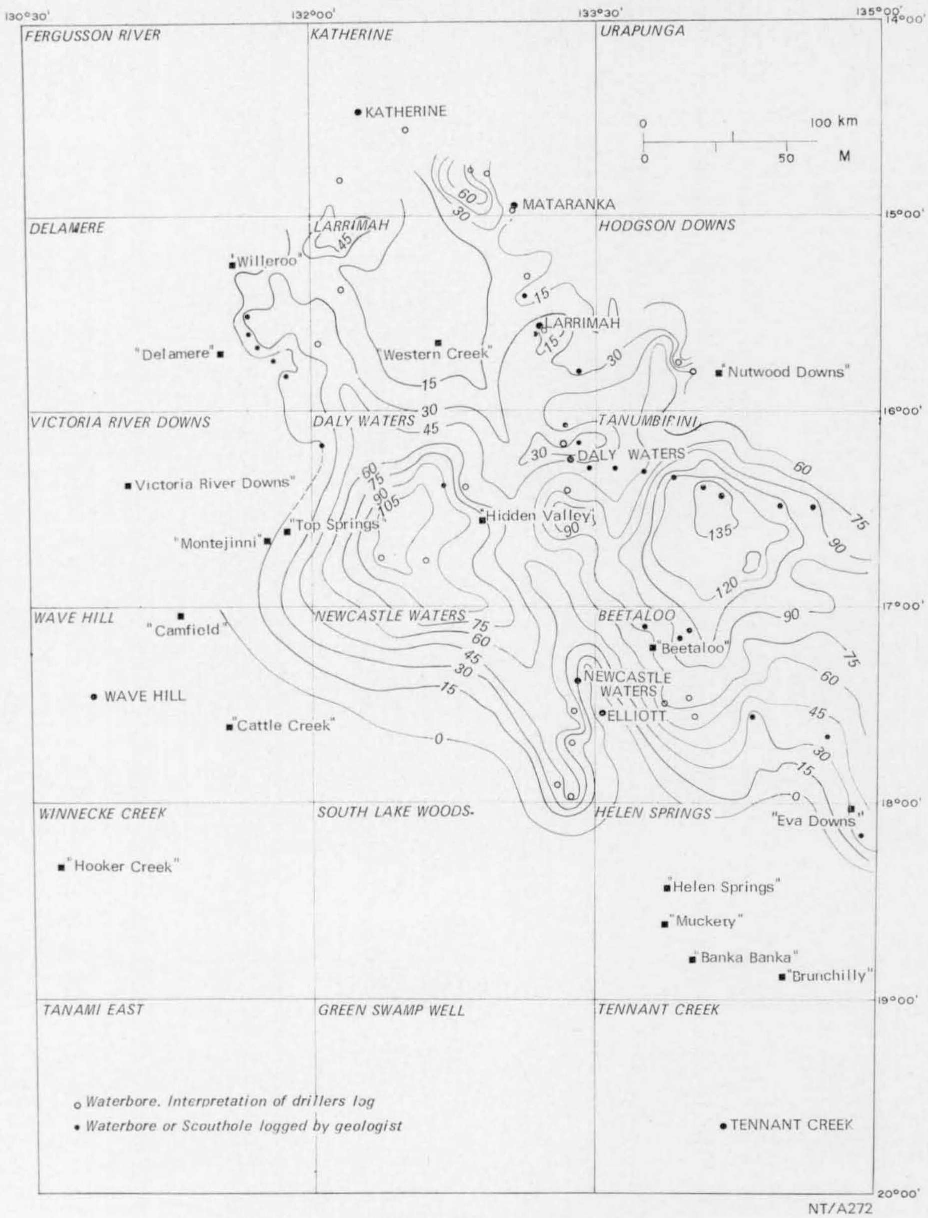

Fig. 3. Isopachs on thickness of Mullaman Beds.

Travertine occurs over basic volcanic and carbonate rocks. Its occurrence is more widespread than shown on the geological map; most outcrops are too small to be shown on the map.

The grassy downs of the Barkly Tableland and the grassy plains west of the Stuart Highway are underlain by black and grey pedocalcic soils developed over Cambrian and Tertiary carbonate rocks and Cretaceous siltstone and claystone. Brown and red-brown clayey soils are developed over basic volcanic rocks and carbonate rocks in the northern part of the region. The clayey soils are moderately to weakly leached and contain layers rich in carbonate and gypsum.

The areas mapped as alluvium include lakes, swamps, flood plains, and flood-outs of streams, and some flat areas of heavy grey and brown soils in old valleys on the Main Plateau.

SURFACE WATER

Climate

The climate in most of the region is semi-arid, rain falls mostly under the influence of the northwest monsoon, which normally lasts in the northern part from November to March—the wet season. The duration of the rainy season decreases from north to south. The remainder of the year is usually without useful rain, although some winter showers do occur. The average annual rainfall ranges from 286 mm at Tennant Creek and 387 mm at Cattle Creek in the south to 854 mm at Katherine in the north. Figure 4 shows the average annual rainfall for the period 1950-1965*. The driest part of the region is the desert country south of Cattle Creek homestead and west of Tennant Creek, which extends westward and southward to the vast dry interior of the continent. Figure 5 shows the mean monthly rainfall at Daly Waters and clearly illustrates the separation of the summer wet season from the winter dry season.

The temperature and humidity in the region are well documented only for the larger towns. Table 2 lists mean extremes of these climatic conditions (CSIRO, 1953, 1954).

TABLE 2. CLIMATIC DATA FOR PERIOD 1911 TO 1940

	Tennant Creek	*Daly Waters*
Mean maximum temperature	31.9°C	34.4°C
Mean minimum temperature	18.5°C	19.3°C
Mean temperature (hottest month)	30.6°C (December)	31.3°C (November)
Mean temperature (coolest month)	17.6°C (July)	20.4°C (July)
Relative humidity (driest month)	28% (October)	39% (September)
Relative humidity (wettest month)	50% (February)	67% (February)

The evaporation over the region is least in the north and greatest in the south. The average annual evaporation for the period 1950-65 is 2250 mm at Katherine, 2850 mm at Daly Waters, and over 3050 mm at Tennant Creek. The average monthly evaporation at Daly Waters is illustrated in Figure 5. It is highest in the wet season and lowest in the dry season. Nevertheless, as in the central Barkly Tableland (Randal, 1967), the evaporation/precipitation ratio is lowest in the wet season and highest in the dry season. This implies that groundwater supplies are restored by summer rather than by winter rains.

To some extent the density of watercourses in the region is proportional to the amount of rainfall: there are fewer streams on the Main Plateau, where the rainfall is lowest, but numerous well defined streams on its western, northern, and

* Figure 4 was prepared using monthly rainfall figures for the period from 17 stations within the region, made available by the Commonwealth Bureau of Meteorology, Melbourne.

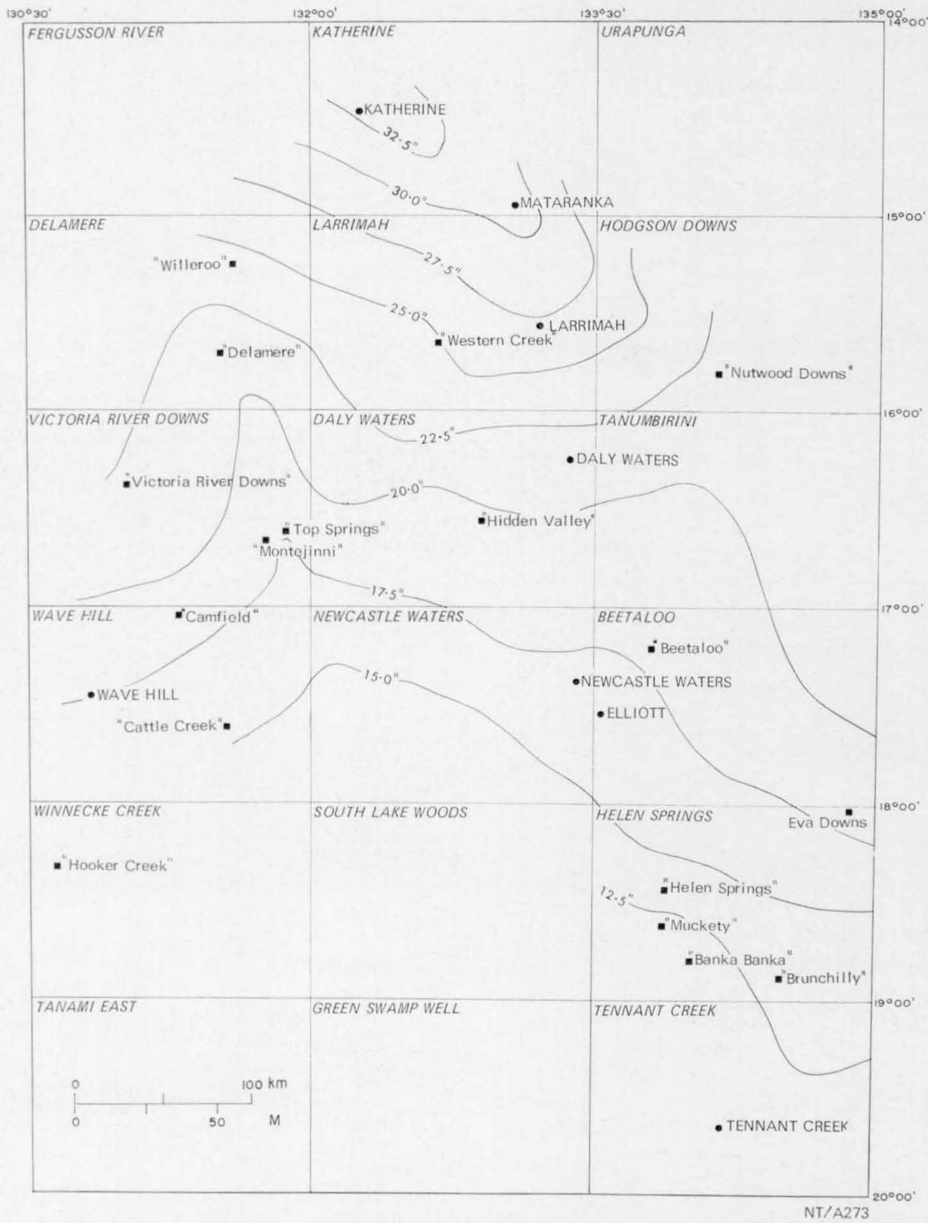

Fig. 4. Isohyets 1950-1965.

eastern flanks, where the rainfall is higher and run-off greater. Because the flanks are more dissected, more waterholes occur there than on the Plateau.

Because of the seasonal and unreliable rainfall and semi-arid climate of most of the region, surface water is inadequate for full pastoral development. The droughts on the Barkly Tableland described by Foley (1957) and referred to by Randal (1967) affected also the eastern environs of the Wiso Basin, i.e. the western and northwestern extensions of the Tableland. From 1896 to 1955, the

Darwin/Daly Waters/Wave Hill area experienced drought periods totalling about 19 years (Foley, op. cit.); in addition, periods of below-normal rainfall, though not themselves severe, prevented the pastoral industry from weathering the drought years which followed soon after. Drought lasted for 16 months from October 1899, and 22 months from April 1901. There was a total of nearly 5 years of drought between 1907 and 1920, and nearly 6 years between 1925 and 1938. Victoria River Downs, Powell Creek, and Tennant Creek had their lowest recorded rainfall in 1928, 1931, and 1935 respectively. From March 1946 to January 1949 rainfalls were below average, and in December 1951 and early 1952 most of the Territory entered into one of the worst droughts it has experienced. Over 10 000 head of stock died on Helen Springs station alone, and it was reported that there was virtually no grass from the Queensland border to the Victoria River district. Most of the permanent waterholes, even the large ones at Newcastle Waters, dried up.

The pastoral industry therefore does not in the main rely on surface waters, but uses them merely to supplement groundwater obtained by boring.

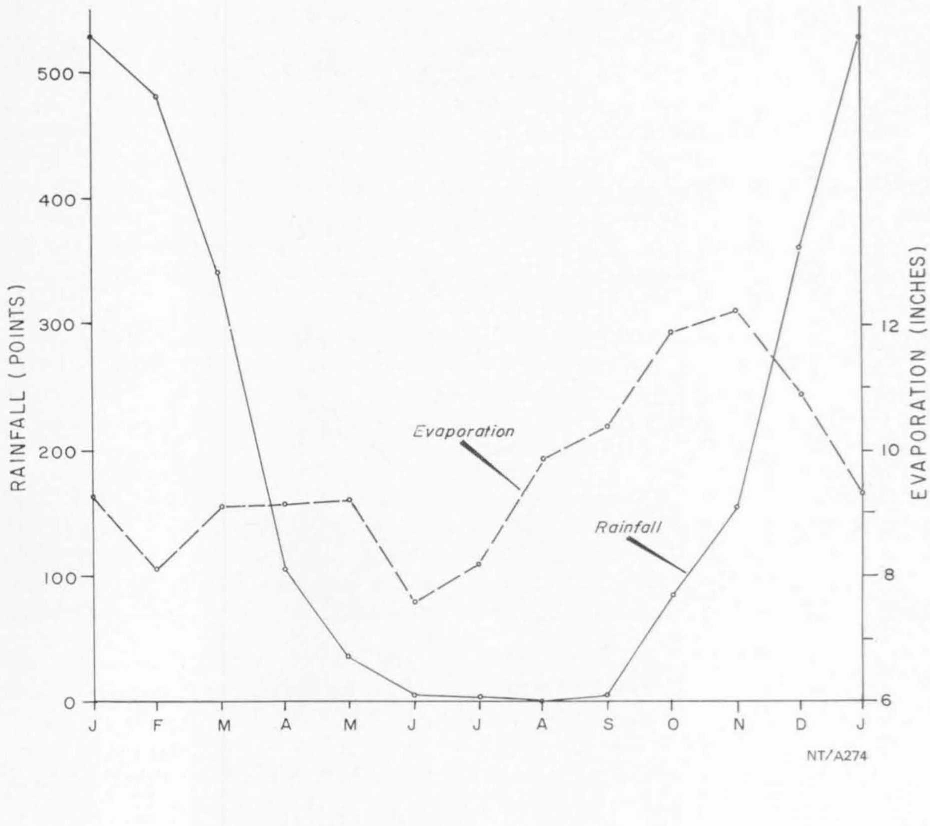

Fig. 5. Rainfall and evaporation at Daly Waters.

Distribution of surface water

Elements of three of the major drainage divisions of Australia occur in this region—the Western Plateau Division, the Timor Sea Division, and the Gulf of Carpentaria Division (AWRC, 1965). Within the region, the Timor Sea Division contains the Victoria River and the Daly River Basins, and the Gulf of Carpentaria Division contains the Roper River and the Limmen Bight River Basins. The boundary between the two divisions is approximately the same as the boundary between the Daly River Basin and the Gulf Fall shown in Figure 1. The Western Plateau Division is a large area of unco-ordinated drainage occupying about one-third of the Northern Territory, two-thirds of Western Australia, and about half of South Australia. In the Northern Territory the Western Plateau Division is approximately co-extensive with Hays' (1967) Main Plateau except for the northern part of the latter. The Main Plateau has a consistent northward decline north of latitude 16°30′S, and much of the drainage there connects with the main drainage systems of the Dissected Margin. Consequently the northern stream-courses of the Plateau have been included in the appropriate coastal drainage divisions by the Australian Water Resources council and the boundary of the Western Plateau Division is about 144 km south of the northern extreme of the Main Plateau. To the west and east the discrepancy lessens and the drainage and physiographic boundaries ultimately become congruent.

The partial discordance between the physiographic and drainage divisions is justified by the geology and geomorphology. The Main Plateau is for the most part bounded in the north by a well defined escarpment formed by the Lower Cretaceous Mullaman Beds, which is a much stronger feature than the low divide at about latitude 16°30′S. Furthermore the northern part of the Plateau is nowhere as well dissected as the main parts of coastal drainage divisions, and is underlain by the same flat-lying rock sequences as the contiguous central part of the Main Plateau. The coastal drainage within the Main Plateau is due to headwater encroachment and capture of originally random drainage elements by the coastal streams. Remnants of the Main Plateau (mesaform outliers of the Mullaman Beds) occur in the coastal divisions. The coastal streams are actively eroding the Main Plateau, and reducing its extent, but the resultant topography is far from being mature enough to warrant strict adherence to the idea of physiographic boundaries coinciding with drainage basin boundaries. Because the distribution of long-lasting surface water is closely controlled by the physiography, it will be described by physiographic divisions rather than drainage basins.

Within the Main Plateau long-lasting and permanent water occurs only in and on the flanks of the Ashburton Range, in the downs and sandy country east of the highway, and north of the Murranji Stock Route (Fig. 6). Very little is known about the occurrence of surface waters in the desert south of the Murranji Stock Route.

Because of the arid seasonal climate there are no permanent streams in the Main Plateau. Most of very few permanent waterholes are on the incised watercourses on the flanks of the Ashburton Range. The more important are in Attack Creek, Morphett Creek, Tomkinson Creek, and Burke Creek. Small permanent waterholes are fed by springs in Gleeson and Powell Creeks, and small semi-permanent rockholes occur in Bootu Creek. These waterholes occur mainly in large depressions in the rocky and sandy floors of the watercourses or are associated with rock-bars forming natural barriers. Most are in country which is not

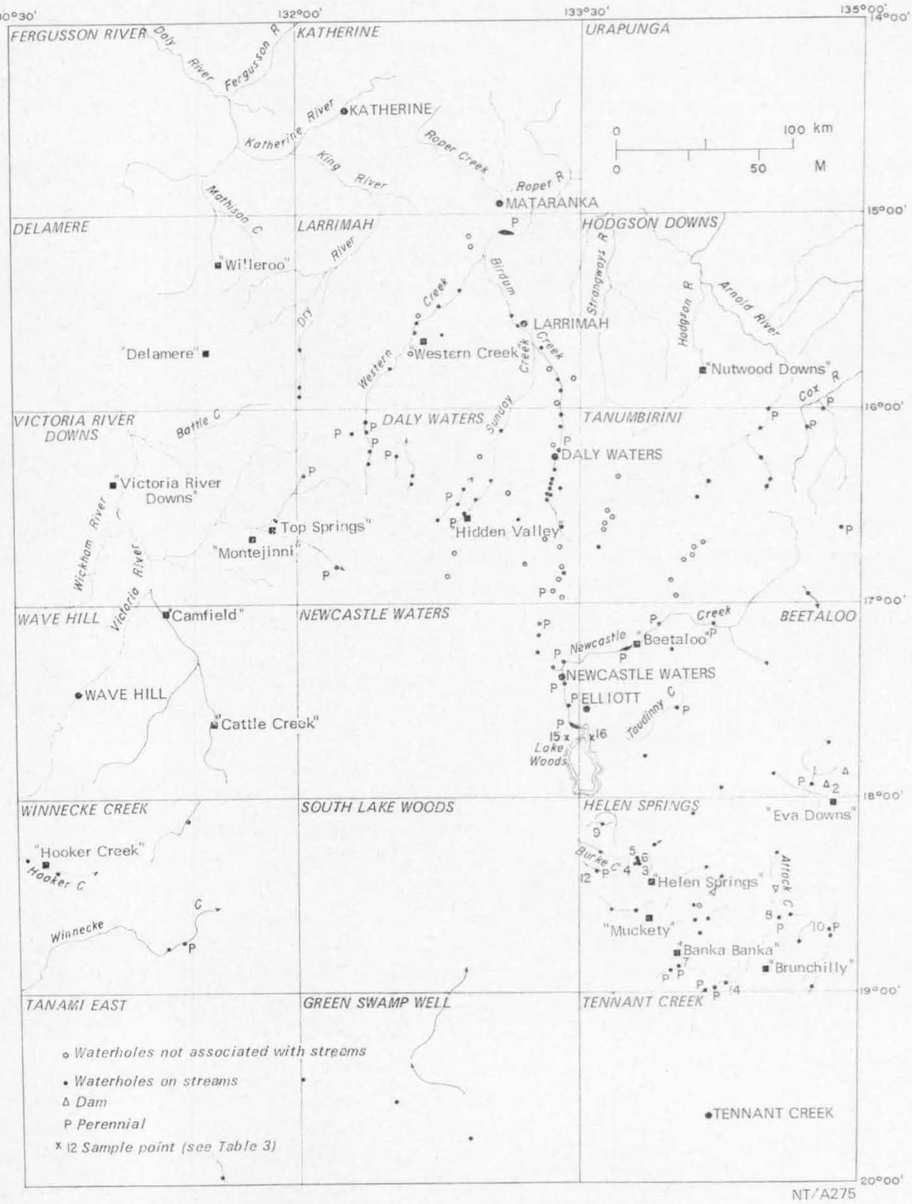

Fig. 6. Distribution of waterholes in the Main Plateau.

very suitable for cattle grazing, which is carried on in the grassy downs east of the ranges, in the sandy and lateritic areas to the east of the Stuart Highway, about Newcastle Creek, and north of the Murranji Stock Route.

In the downs country Coolunkie Waterhole on Brunchilly Creek and Munkaderry Waterhole on the northern extension of Attack Creek are the largest permanent surface waters. Indamilly Waterhole on McKinley Creek, though large, is regarded by local pastoralists as not normally perennial. Numerous depressions in the watercourses in the downs country form waterholes of varying importance, but most are dry by the middle of the dry season. North of Eva Downs normally perennial water is available at Surveyors Waterhole on Broad Creek. Surface water is conserved by dams; the largest of these is Brunchilly Dam on Brunchilly Creek, in which permanent water is backed up for 1 km in June. Other permanent supplies are at 6-mile dam and 10-mile dam, north of Eva Downs. Small dams on Carmilly and Attack Creeks have insufficient depth and catchment to be normally perennial.

Permanent waterholes occur in Newcastle Creek. Important ones east of the Stuart Highway are Mundah and Hollomo Noon east of Beetaloo, and a large one at Beetaloo homestead. Newcastle Waters station and township are named from an almost continuous line of waterholes, many permanent, extending 48 km southward from the Stuart Highway to near Lake Woods. The permanent waterhole near the township is 2 km long and that near Lake Woods over 6 km long. There are several waterholes, some normally perennial, in the northern tributaries of Newcastle (Waters) Creek. The more important of these occur along Bucket Creek, which is followed for 26 km by the Murranji Stock Route. Surface water along the Murranji Stock Route is scarce, and between Howells Ponds on Bucket Creek and Yellow Waterhole 120 km to the northwest the only notable waterhole is the Murranji, after which the route is named, and this is usually dry by August. Hence, until bores were constructed along the route in about 1920, it was considered one of the most hazardous in the Northern Territory.*

There are numerous waterholes on the Plateau north of the Murranji Stock Route, but most are not perennial and very few can be safely regarded as permanent. The waterholes along Daly Waters Creek are many but frequently fail before the end of the dry season. Similarly the waterholes northward from Daly Waters in the valley of Birdum Creek cannot be relied upon as perennial supplies. Brown (1895) describes his difficulties in obtaining water along this creek in December 1894 despite several heavy rainstorms. Stuart Swamp, 6 km north of Daly Waters, is normally perennial. In the central part of the Daly Waters Sheet area several streams are partly incised on the northern flank of the low divide about latitude 16°30′. Many waterholes occur in these streams at points of reduced gradients. Several are regarded as perennial, but even some of these may fail if the wet season is either abnormally late or is poor for some years in succession. The most important occur in the upper reaches of Western, Middle, and Sunday Creeks. On the western side of the Plateau permanent water occurs in Nelly Creek. Few of the several waterholes in the headwaters of the Dry River are perennial.

South of the Murranji Stock Route waterholes occur in Winnecke and Hooker Creeks. Some may be perennial for a few years after successive good wet seasons, but are not regarded as reliable. The most important are Merrina Waterhole and the Duck Ponds on Winnecke Creek. Chewings (1930) did not consider the waterholes he visited to be permanent, and suggested that most surface waters would be dry three months after the end of the wet season. K. G. Smith and H. F. Doutch (BMR, pers. comm.) flew over most of the Wiso Basin in 1965 and reported several pools of water in clay pans and in interdune corridors, but considered that these would have dried up in a few weeks. They resulted from heavy storms a few weeks earlier. In August 1966, three weeks after heavy winter rain, the author noted damp mud in shallow depressions 128 km south of the Murranji Stock Route. Several waterholes recognized on aerial photographs appear not to be permanent.

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* The improved watering facilities did not, however, alleviate the difficulties of droving cattle through close tangled scrub and stands of lancewood which are traversed for most of the journey from No. 10 Bore westward to the edge of the Plateau.

An interesting feature of the Main Plateau is the occurrence of waterholes, both perennial and ephemeral, not in defined watercourses but in subcircular or elliptical depressions towards which the drainage from a small area is directed. They occur mostly in outcrop or shallow subcrop areas of the Lower Cretaceous rocks or in the areas of sand and recemented lateritic gravel. They appear to be the surface reflection of collapse in the Cambrian carbonate rocks beneath the younger sediments. Many have steep banks of recemented detrital laterite or soft lateritized Lower Cretaceous sandstone and siltstone, but erosion has bevelled the edges of several, permitting some ease of access, and very little of the original banks of others are left, the hole being merely a depression with a silty or clayey floor and marginal slopes of the same material containing a few remnants of sandstone, siltstone, or ironstone, e.g. Murranji Waterhole and Huddleson Lagoon, neither of which is perennial. In addition to these, other waterholes of this type are Frew Pond and Brolga Waterhole (Western Creek homestead), which is normally perennial, and Moorak, Mering Mering, and others, between Hidden Valley homestead and Daly Waters, which last throughout the dry season only after successive good wet seasons. The holes are replenished by direct precipitation, surface drainage, and lateral percolation through surrounding soil and unconsolidated sediments. The water appears to be retained by a mulch of vegetable matter and fine silt. Some are losing storage capacity through excessive silting.

There are numerous waterholes in most of the creeks and rivers of the Victoria River plains and terraces, but very few are permanent. Although surface flow in the Victoria River ceases some weeks after the end of the wet season, long pools of permanent water occur along the river from Wave Hill settlement to its mouth. Smaller permanent waters occur in the Camfield and Armstrong Rivers and Coolibah Creek. The permanence of the holes in the Victoria River is due to its depth —the river is deeply entrenched—and the protection from wind afforded by the abrupt and heavily wooded banks. Spring flow may be a contributing factor, but this has not been established.

In the Daly River Basin, only the Daly, Flora, and Katherine Rivers are perennial. The other major watercourses normally flow only during the wet season and for a few weeks thereafter, but contain numerous large waterholes, many of which are permanent. Even the Flora and Katherine Rivers may cease flowing towards the end of the dry season after an abnormally short wet season, but they always contain very large deep waterholes. Two important normally perennial waterholes are Kowai and Wongala on the King River; they supported the Dry River Stock Route before bores were constructed along it.

The only perennial stream in the part of the Dissected Gulf Margin within the region is the Roper River; it may cease flowing towards the end of the dry season following abnormally short wet seasons, but like the major streams in the Daly River Basin, it always contains long pools of water. Elsey Reach in Elsey Creek (a southern tributary of the Roper) contains numerous holes; a few are perennial for some seasons but none are permanent. The Warloch Ponds along Elsey Creek—famous as the locale of the factual novel 'We of the Never Never' by Mrs Aeneas Gunn—is a wide depression between the railway and highway crossings of the creek 10 km long and of varying depth. By the middle of the dry season it shrinks to a chain of mostly shallow waterholes, few normally perennial. Some of the numerous waterholes along the Hodgson, Arnold, and Cox Rivers are permanent.

Springs and very shallow groundwater

There are several springs within the Ashburton Range, along the western edge of the Main Plateau on the watershed of the Victoria River, and in parts of the Daly River Basin and in the Gulf Fall Division, but very few are permanent. 'Springs' have been reported in the featureless sand-dune country of the Wiso Basin, but Chewings (1930) visited some of these in 1909 and regarded them more as native wells and soakages.*

Within the Ashburton Range the most important springs are at Renner Springs, where three sources have been developed and apparently provide an adequate supply to the roadhouse for domestic and stock purposes. They discharge into earth dams which also collect surface run-off during wet weather. Two are situated east of the highway, one immediately north of the roadhouse (north spring), one near the racecourse (southeast spring), and one west of the highway and a few hundred metres south of the roadhouse (southwest spring). The springs occur on the flanks of a low rise of quartzitic sandstone and the water appears to come from coarse gravel and sands partly overlying it. The north spring issues from a depression in the side of a mound of gravel, sand, and sandstone boulders; the water temperature was 26.8°C and air temperature 32.2°C. The southeast spring is in a depression enlarged by excavation; the water level was close to the rim of clayey black soil. At the time of inspection, wind pumping was apparently keeping pace with the flow, as the level remained constant. There was evidence that the water overflowed the rim on occasions. The water temperature was 29.4°C. The southwest spring has been developed as a well about 3 m deep. The well was making water at the time of the visit, but only a few centimetres of water lay in the bottom and the pump was on the point of forking. Flow into the well was by seepages to within one metre of the top of the well, which was dug in partly compacted sand, sandy clay, and gravel. There was no indication of water ever overflowing; the well may have been an exploratory one rather than the development of a true spring. The water temperature was 27.8°C.

Although no detailed work was done in this area, the impression gleaned was that no regional aquifer was providing the supply and that the springs could fail after successive dry years. The area about the springs, though studded with small outcrops, is a plain of superficial deposits forming part of the watershed of Renner Creek, which flows eastward through high strike-ridges of the Tomkinson Creek Beds. Possibly the main water storage and movement is in these superficial deposits, with discontinuous clayey bands confining water in places and creating a perched watertable in others. Meagre evidence for this is the water temperature. Brown (1895) measured the water temperature as 92°F (33.3°C) with an air temperature of 98°F (36.7°C) in January—a hot month. In October 1965 the author measured the water temperatures as 26.8°, 27.8° and 29.4°C with an air temperature of 32.2°C. These readings suggest that the water temperature is affected by air temperature and hence the zone of saturation may be very shallow.

No flowing springs were found at Helen Springs at the time of the author's survey, but Brown visited them in 1895 and states: 'The Spring rises from an

* In the case of the wells no water was visible at the surface before they were dug, and even after, water merely collected in the bottom of the holes and did not rise to the surface. In the soakages, water lying in small depressions was replenished after removal—by exploitation or evaporation—by movement of water from the adjacent saturated alluvium.

uptilted bed of flaggy sandstone overlaid by decomposed amygdaloidal basaltic rock.' This sandstone, the basal rock of the Helen Springs Volcanics, is the aquifer supplying the garden and homestead wells at Helen Springs homestead. The basalt in the vicinity is lateritized and heavily weathered and the resulting kaolinitic debris apparently acts as a confining bed. The basal sandstone also provided a good supply of water in scouthole HS 6.

In a small creek south of Powell Creek and in Gleeson Creek, springs issuing from jointed sandstone of the Tomkinson Creek Beds maintain small permanent waterholes. Other springs along the flanks of the Ashburton Range are not perennial and have not been investigated in detail. They occur in alluviated valleys bordered by large elevated areas of jointed sandstone, or issue from joints and fissures on the slopes of sandstone ridges. Some may be controlled by faulting. Groundwater does not necessarily circulate deeply in the Tomkinson Creek Beds: the Powell Creek Telegraph Station was adequately served by a well 11 m deep in sandstone and quartzite; the water stands 4 m below ground level, and water possibly from the same aquifer forms a soakage in the creek nearby. Similarly, Wiggenty Well on Muckety station is constructed in this unit and the water stands at 3 m below ground-level.

Springs are reported to occur in the folded Precambrian rocks in the Hodgson Downs and Tanumbirini Sheet areas, but were not visited during the survey. Warm springs associated with faults in limestone occur in the Waterhouse River near its confluence with the Roper River east of Mataranka. Similar springs occur in the Douglas River, in the northern part of the Daly River Basin. Several springs have been noted over the years on the western terraces bordering the Main Plateau. Only a few were visited during the survey and only one, Pandanus Springs south-west of Willeroo, appeared to be perennial; but green vegetation at the sites of others testified that water was about long after other holes nearby had dried out. Pandanus Springs are associated with sandstone beds in the Antrim Plateau Volcanics; other springs in the Volcanics owe their existence to impermeable chert beds. Some reported springs may occur at the disconformity between the Volcanics and the overlying Montejinni Limestone, but this was not confirmed during the recent survey.

As indicated earlier, Chewings investigated shallow groundwater in the Wiso Basin in an attempt to establish watering points for a proposed stock route from Barrow Creek to Wave Hill; he sank several shallow wells in the vicinity of existing native wells and soakages and obtained water at Hit or Miss, Native, Green Swamp, and Cattle Swamp Wells. The water occurs in travertinous limestone* or in sandstone immediately below it. The wells are less than 3 m deep and the water, which Chewings described as fresh, rose to within a metre or so of the surface. Chewings also made shallow trial borings and reported some salty water. He regarded the wells as permanent, but he travelled through this country during the period April to July, i.e. in the early and middle parts of the dry season, and it cannot be assumed that the watertable will be maintained above the bottom of shallow wells throughout the dry season. Scouthole GSW 4, drilled in July, encountered a seepage at 63 m in Tertiary sediments, the water rising to within 3.3 m of the surface. Also, Bobs Well in the Lander River Sheet area to the south of this region obtains 0.95 *l*/s (750 gph) of brackish water from a depth of 11 to 14 m, the standing water level being 11 m.

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* Perhaps more correctly surface calcrete.

Quality of spring and surface water

The spring and surface waters of this region are chemically suitable for stock and domestic use, but some holes are polluted by stock. This can of course be controlled if necessary by suitable fencing and reticulation. Table 3 presents the analyses of waters in the eastern part of the region.

The waters generally have a low salinity—only three contain more than 200 ppm of total dissolved solids, and to some extent these three high values may have been due to non-filtrable matter in suspension being included in the determination. A very striking feature of most waters of the Main Plateau is moderate to extreme milkiness caused by colloidal suspension of clay particles apparently derived from the clayey soils over which the water has passed. The effect is not restricted to the downs country, as waterholes in the laterite and sandy areas north of the Barkly Stock Route and north of the Murranji Stock Route also exhibit it. The water issuing from the north spring at Renners Spring Roadhouse is clear, but that accumulating in the dam is very milky. The many waterholes on the flanks of the Ashburton Range in Attack Creek contain very clear water, but some kilometres downstream in the downs country Attack Creek Dam contains milky water. The total dissolved solids could not be determined for two samples, Nos 15 and 16 from Lake Woods, because too much finely suspended matter (0.5 microns or less) passed through the filter paper. Waterholes in the Ashburton Range and on its flanks normally contain clear water, as do those in the major streams of the Daly River Basin, the Victoria River system, and the main watercourses of the Gulf Drainage System.

The waters have a very low fluoride content: water from the dam at Renner Springs contained 1.3 ppm, but all other samples contained less than 0.8 ppm. The nitrate content is normally low—less than 10 ppm. Two values much higher than the others suggest pollution by stock. These are from the samples taken at Brunchilly Dam (19.8 ppm) and Coolunjie Waterhole (16.5 ppm). Coolunjie Waterhole is not fenced, and at the time of sampling the fencing around Brunchilly Dam was in disrepair and stock had direct access to the water. The springs at Gleeson Creek and Renner Springs are interesting inasmuch as the nitrate content of the spring water is somewhat higher than that for the same water lying on the surface.

The samples from Renner Springs (Nos 5 and 6) and Gleeson Spring (Nos 9a and 9b) clearly show the effects of concentration by evaporation. In both the total salinity has been more than doubled, but the various constituents have not increased by a constant factor. Randal (1967) noted similar differences resulting from the concentration of groundwater stored in a raised earth tank. An interesting feature is the very high increase of potassium and sodium compared to a decrease in magnesium and calcium.

Generally bicarbonate* is the dominant anion, reflecting the availability of atmospheric carbon dioxide, and in the limestone areas, the availability of carbonate ions which normally are transformed to bicarbonate ions. However, the sample from Surveyors Waterhole showed a higher proportion of sulphate ion, and that from Attack Creek Dam a higher proportion of chloride ion, than is normally encountered in surface waters. Nevertheless, both were dominantly bicarbonate in com-

* The relative dominance of the constituents is based on the concentration expressed as equivalents per million, not parts per million.

TABLE 3. CHEMICAL ANALYSES OF SPRING AND SURFACE WATER

Name	*Ca*	*Mg*	*Na*	*K*	*Cl*	SO_4	HCO_3	*F*	SiO_2	NO_3	*Sp. Cond.*	*pH*	*T.D.S.*
(Numbers shown on Figure 7)													
						Beetaloo Sheet Area							
1. Surveyors Waterhole	8.4	5.0	2	3	6.9	12.8	21.6	0.4	29.8	9.8	78.3	6.10	51.4
2. 6-Mile Dam	4.6	2.8	2	2	1.0	8.2	27.8	0.3	16.1	4.0	48.5	6.70	178
						Helen Springs Sheet Area							
Renner Springs:													
3. Southeast Spring	9.2	8.1	23	7	22.0	17.3	89.5	0.4	20.5	9.6	238	7.30	147
4. Southwest Spring	8.4	9.7	27	7	23.5	19.3	104.9	0.8	25.1	7.7	275	7.00	182
5. North Spring	27.7	8.8	26	8	240	15.6	154.3	0.4	23.4	3.9	349	7.50	183
6. North Dam	22.2	17.6	5	27	61.0	25.5	345.6	1.3	31.7	3.5	751	7.40	416
7. Morphett Creek Waterhole	6.7	3.6	7	7	11.8	5.3	43.2	x0.1	1.0	7.1	126	6.50	72
8. Monkaderry	31.5	10.5	9	17	23.6	10.7	152.2	0.2	8.1	8.4	315	6.80	197
9a. Gleeson Spring Creek	3.9	4.5	26	5	0.94	0.12	49.4	0.5	66.3	2.3	183	5.80	346
9b. Spring	6.9	5.3	11	4	14.7	2.1	53.7	0.1	36.2	5.0	162	6.60	136
10. Coolunjie Waterhole	20.9	3.8	6	9	1.5	11.5	89.5	0.4	31.6	16.5	169	6.95	131
11. Brunchilly Dam	21.7	11.5	6	12	5.4	9.1	132.7	0.3	28.3	19.8	246	7.00	174
12. Burke Creek Waterhole	12.6	5.1	6	8	13.5	6.6	77.2	0.1	14.6	1.5	160	6.95	137
13. Attack Creek Dam	41.8	16.2	33	35	87.5	35.8	160.5	0.6	4.8	x0.10	585	6.90	412
14. Attack Creek Waterhole	18.6	8.6	20	8	30.5	6.6	96.9	0.1	30.6	1.2	266	7.30	186
15. Lake Woods (West)	8.2	0.71	2.3	9.0	x	10.7	39.4				69.9	6.9	
16. Lake Woods (East)	14.0	1.26	1.2	7.6	x	8.7	59.1				96.2	7.3	

Analyses in parts per million (ppm); specific conductivity in micromhos/cm.

position and in the terminology of Randal (1967) would be classified as sulphate-bicarbonate and chloro-bicarbonate respectively. The others would be classified as mainly bicarbonate. The source of sulphate is readily apparent—the soils are gypsiferous in places—but the source of chloride is not.

Calcium and magnesium are generally the dominant cations in the surface waters, but sodium is dominant in some, particularly in non-carbonate areas.

GROUNDWATER

DEVELOPMENT

History of groundwater use

Except for the use of springs and the sinking of wells by explorers, groundwater in this region was first used by construction workers building the Overland Telegraph Line. This project began in 1871, and the lack of progress towards the end of the dry season was attributed to the diversion of manpower to sink wells as the surface waters were rapidly failing (Bauer, 1964). Unlike the Powell Creek Station Well, reputed to be 12 m deep, not all the wells were shallow. Some along the line near Birdum Creek were reported by Brown (1895) to be 100 ft (30 m) into limestone, and he records a dry well 200 ft (60 m) deep in limestone at Daly Waters.

Stock were introduced into the region early in the history of the Northern Territory. Spring Vale station near the present Manbullo homestead was taken up in 1876 and stocked with sheep and cattle in 1879. About 1881 the sheep were moved to the Delamere country from Spring Vale and the same interests opened up Newcastle Waters. Elsey was taken up in about 1877. Eva Downs, Helen Springs, Renner Springs, Wave Hill, and Victoria River Downs were taken up and stocked in the early 1880s. Brown (1895) referred to the springs at Helen Springs and Renner Springs, noting that those at Renner Springs had been developed for stock use; he also referred to a well in Cretaceous rocks at Eva Downs. Generally, however, stock depended on waterholes, some of which were spring-fed for part of the year.

Whereas the eastern part of the Barkly Tableland was mainly influenced by pastoral practices in Queensland, the activity in this part of the Northern Territory reflected the lethargy and ill-luck that dominated most enterprises in Darwin and the top end of the Northern Territory*. Hence, although drilling for groundwater began in the Barkly Tableland in the early 1890s (Randal, 1967) shortly after the early successes in Queensland, it did not begin in the study area until nearly 25 years later (Fig. 7). The first recorded drillings were Wave Hill Bores Nos 1 and 2 in 1915, 3 years after the station had been acquired by the Vestey organization. The bores were successful and several more were drilled in the following years on both Wave Hill and the adjoining Victoria River Downs. The first failure was No. 8, drilled in 1919. The early successes were remarkable inasmuch as many of the holes drilled on the station after the first failure have been dry or yielded inadequate supplies.

* The early history of the pastoral industry in the Northern Territory generally and in the northern part of the Territory is described in some detail by Duncan (1967) and Bauer (1964) respectively.

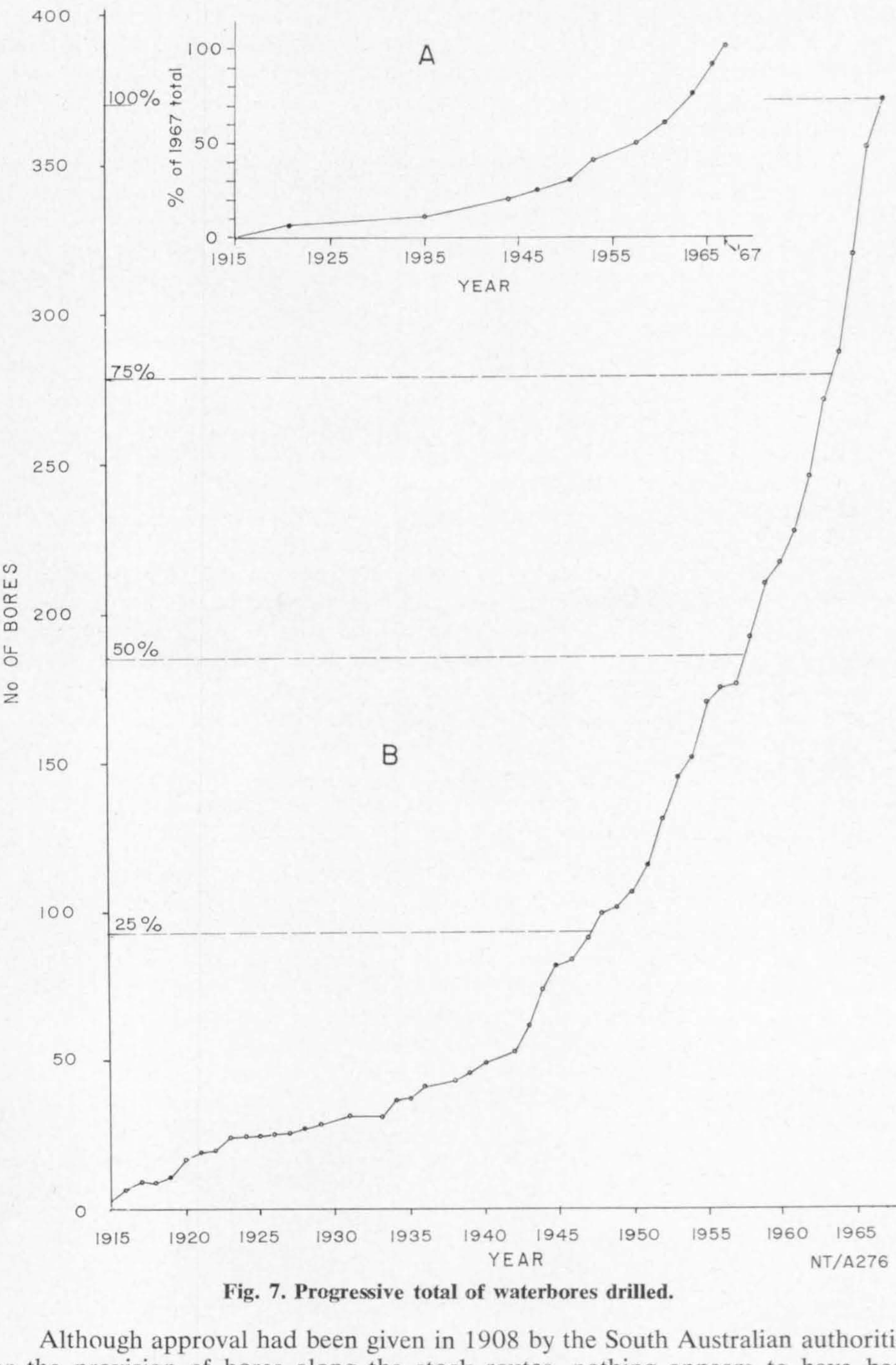

Fig. 7. Progressive total of waterbores drilled.

Although approval had been given in 1908 by the South Australian authorities for the provision of bores along the stock routes, nothing appears to have been done until about 1916-1919, when some bores were constructed along the Dry River Stock Route. Presumably some of the bores along the Birdum Stock Route were drilled about the same time. The Murranji Stock Route and the Barkly Stock

Route were probably the most important stock routes in the early development of the region, particularly after Buchanan found a crossing of the Barkly Tableland in 1877, for they permitted access to the Kimberley country for cattle from Queensland and later gave pastoralists in the west access to eastern markets. Yet the bores (Nos 1-8) along the Anthony Lagoon Stock Route (now the western part of the Barkly Stock Route) from Anthony Lagoon to Newcastle Waters were not drilled until 1920 and 1921. Murranji No. 9 was drilled in 1921 and the remainder in 1923. Muckety Bore, drilled in 1925, and an unsuccessful bore near Renner Springs appear to be the first drilled between Newcastle Waters and Tennant Creek on the North-South Stock Route. Most of the others followed in 1934. On the recommendation of Ward (1926), three bores were drilled on the Wave Hill Stock Route between 1928 and 1931.

In 1928 Banka Banka station drilled its first two bores and appears to have been at that time the only station in the region to follow the example of Wave Hill and Victoria River Downs. In 1934, bores in addition to those on the North-South Stock Route were drilled both at Newcastle Waters township and at Newcastle Waters homestead. Eva Downs in the western Barkly Tableland drilled its first bore (A Bore) in 1938. By 1940, including replacement drilling alongside earlier bores, there were only about 60 bores in the region, of which about 20 were on the one station—Wave Hill—and about 20 were stock route bores. At this time there were twice as many in the central and eastern part of the Barkly Tableland. Although drilling on private holding in that part of the Tableland virtually ceased during the war years (1939-45), it continued on Wave Hill, Banka Banka, and Helen Springs, and on stock routes. During this period numerous bores were drilled at Army and Air Force establishments along the Stuart Highway, notably at Birdum, Larrimah, and Katherine, and at Gorry, Venn, and Tindall Aerodromes between Birdum and Katherine. In the late 1940s drilling continued on those stations which already had drilled bores; additional bores and replacements were drilled along the stock routes. In 1949 Brunchilly No. 1 Bore was drilled.

The early 1950s saw an expansion of the cattle industry which was reflected in the increased drilling in this region as well as the east (Randal, 1967), but even so most of the activity was in the western Barkly Tableland part of the region. However, during the 1950s several blocks were separated from Victoria River Downs, and early improvements on these—Killarney, Montejinni, and Camfield —maintained the drilling activity in the later 1950s. The early 1960s saw added activity, mainly as a result of the government advice scheme for pastoral bores. In this scheme the Commonwealth provides technical advice on the selection of bore sites, advances money for the cost of successful bores, and underwrites the cost of failures. During this period bores were drilled on most stations. From the mid-1960s to the present there has been a great deal of drilling, but not all has been directly for pastoral purposes. Numerous bores have been drilled for town supplies and for construction purposes. Important amongst these are exploratory bores at Katherine for an improved town supply, bores at Top Springs and Wave Hill, and construction and domestic bores at Tindall and Venn Airfields. Since about 1963 these bores have far outnumbered those drilled for direct pastoral use.

Present development

Although the general pattern of drilling activity in this region has followed that in the Barkly Tableland to the east (Randal, 1967), it has been distorted by the number of holes drilled for public purposes not directly associated with pastoral development. These are the bores mentioned above—developed town-supply bores, exploratory bores for additional town supplies, and road and airfield construction bores. This region is astride the major lines of transport between Darwin and the south and east and between Darwin and Western Australia. Accordingly it contains several townships, and considerable work is done on road improvements. The first factor is negligible in the Barkly Tableland and the second comparatively much less important. A large number of bores exist in the region, but most are concentrated in the better grazing lands of the western Barkly Tableland and the eastern Victoria River region, and along the Stuart Highway, particularly between Larrimah and Katherine townships. Large tracts of land between the Katherine/Top Springs Road and the Stuart Highway contain very few pastoral bores and there are none south of the Murranji Stock Route between the western environs of the Ashburton Range and Hooker Creek.

Table 4 gives the density of working bores on selected pastoral properties. Those properties which rely mainly on surface water or are in the early stages of development are not listed.

The highest density is on Eva Downs and Brunchilly stations in the western Barkly Tableland, and the other Tableland stations also have a high density of bores compared to most of the others in the west of the study area. Newcastle Waters is an exception; it and Montejinni station have the lowest bore density listed. However, Newcastle Waters contains a large tract of land west of Lake Woods unsuited to grazing, and if this is excluded the bore density on the holding is more in keeping with other stations on the Tableland. It is interesting that in the flinders and mitchell grass areas on Wave Hill station the bore density is very close to that of the central and eastern Barkly Tableland—84 square miles (218 km^2) per bore (Randal, 1967).

TABLE 4. BORE DENSITY ON PASTORAL HOLDINGS

Station	*Area (km^2)*	*Number of working bores***	*Area served per bore (km^2)*
Banka Banka	3315	16	207
Brunchilly	3238	16	202
Camfield	2725	12	227
Eva Downs	2802	14	200
Helen Springs	5393	21	257
Killarney	2841	10	284
Montejinni	3149	8	394
Newcastle Waters	10370	27	384
Ucharonidge	2482	7	355
Wave Hill	5200***	24	218

* As shown on the Pastoral Map of the Northern Territory, 1967, and converted to square kilometres.

** Includes bores idle but serviceable.

*** The pastoral map shows the area of Wave Hill (including Cattle Creek) as 6158 square miles (15 950 km^2). However, all the bores are concentrated east of the Victoria River and north of latitude 17°50′S, in an area of about 2000 square miles (5200 km^2).

Table 5 shows the linear density of bores on the major stock routes in the region.

TABLE 5. DENSITY OF STOCK ROUTE BORES

Stock Route	*Section considered*	*No. of bores*	*Average distance between bores (km)*
North-south	No. 6 Barkly to Banka Banka—96 km	5	24
Barkly	Eva Downs to Elliott—192 km	8	23
Murranji	Newcastle Waters to Top Springs—232 km	9	29
Dry River	No. 1 to Top Springs—272 km	10	30
Wave Hill	Top Springs to Wyalong—90 km	5	22
Birdum	No. 1 to 8A Causeway—240 km	9	30

Although the better grazing areas in the region have a bore density comparable to that of the well grassed Barkly Tableland, additional bores will certainly be drilled in them. It is extremely difficult to predict a trend in the expansion. There are no signs that any of the stations intend to embark on a program such as occurred on Brunette Downs in the early 1960s, when over 70 bores were drilled in three years. The graphs in Figure 7 indicate accelerating development, and, even allowing for the distortion of the trend caused by construction drilling, at least five new pastoral bores per year can reasonably be expected. This is especially so if pastoral economics warrant the further development of the smaller individually owned holdings. Pastoralists throughout the region have recently sought technical advice for the selection of bore sites; many sites have been selected by the resident geologists of the Northern Territory Administration, but at the time of writing most had not been drilled.

Very little new drilling can be expected on the existing major stock routes. Since the inception of cattle trucking along improved roads the stock routes are now infrequently used, although the bores along them are maintained. The distances between watering points on the major routes are reasonable for walking stock and further development is unlikely. Further drilling could be expected for replacement bores or for bores along newly developed short stock routes along which trucking is not economical. Drilling was carried out in 1966 and 1967 along the Auvergne Stock Route to the west of the region.

Four small towns and two large native settlements in the region obtain water supplies from groundwater. Another small town is being developed. A larger one, Katherine, draws most of its requirements from surface water.

At Newcastle Waters (population 91) a bore providing 1.81 *l*/s (1440 gph) was drilled to 188 ft (58.3 m) in 1934, but the supply eventually dropped to 0.76 *l*/s (600 gph). A new bore was drilled to 328 ft (108 m), but the supply recorded is only 0.82 *l*/s (650 gph). The latter supply is presumably adequate for present needs. Daly Waters (population 29) obtains its supply from a bore at the aerodrome. A standby bore on Daly Waters Creek is Birdum Stock Route No. 4A. Little information is available about these bores but the aerodrome bore is engine-pumped and the flow is about 1.25 *l*/s (1000 gph).

Larrimah (population 59) also has an engine-pumped town bore. Many bores were put down in the Larrimah area by the Armed Services and the Department of Works. Records are scant and it is difficult to relate them to the bores in use. However, 3600 gph (4.5 *l*/s) was recorded for one bore described as being near the police station and 1600 gph (2.0 *l*/s) for one of the railway bores. At Wave Hill settlement (population 109) the police station and school bores each yield about 1.25 *l*/s (1000 gph) from sediments of the Victoria River Group. Hooker Creek settlement (population 429) obtains groundwater from the Antrim Plateau Volcanics and the Victoria River Group. The total supply from the three producing bores is 4.67 *l*/s (3700 gph). However, the main producing bore (2.5 *l*/s, 2000 gph) is likely to become polluted and may be taken out of service. Because of this and further development of the settlement, additional sites are currently being investigated (Laws, NTA, and BMR file notes).

Katherine (population 1302) obtains most of its water from the Katherine River, but investigations with a view to supplementing the supply from groundwater are under way, mainly because of seasonal high turbidity in the river water. Several exploratory bores have been drilled in the alluvium adjoining the river channel and high yields (up to 11 *l*/s, 8800 gph) have been obtained at about 9 m. Although some high yields from lower Palaeozoic aquifers in the vicinity of the town are recorded, they vary, and the quality presumably is not as acceptable for a town supply as that of the water from the alluvium. Bores have been drilled for other purposes than exploration: two on the sportsground and others on nearby experimental farms. The supplies range from 1.25 to 7.5 *l*/s (1000-6000 gph), and one bore is reputed to yield 31 *l*/s (25 000 gph).

Numerous bores have been drilled in the vicinity of Tindall Airfield and a few near Venn Airfield for reconstruction work and domestic requirements, but it is difficult to estimate what the usage has been. However, only domestic supplies will be a continuing draft on the groundwater reserves.

Considerable groundwater development is taking place in the region owing to highway reconstruction, particularly along the Katherine/Top Springs/Wave Hill Road and along the Cape Crawford Road from Daly Waters eastward to Borroloola. Several bores were drilled in 1966 along the Top Springs Road, and most gave yields between 2.5 and 5.0 *l*/s (2000 and 4000 gph). Fourteen bores, including four replacements, were drilled in 1967 along a 160-km stretch of the Cape Crawford Road. The bores will be used for watering the gravel subgrade preparatory to sealing, and each will presumably provide the requirements for a 16-km stretch of road.

On the assumption that a 10 percent moisture content is required for a total of 30 cm of subgrade and a pavement 7 m wide, about 3200 m^3 is needed from each bore. This could be met by pumping a bore yielding 2.5 *l*/s (2000 gph) for 8 hours a day for 44 days. This rate could be met by a reasonably good pastoral bore. Further, the total withdrawal per bore is about one-seventh of the volume considered by Randal (1967) to be the maximum annual withdrawal per bore in the central and eastern Barkly Tableland*. Consequently the main consideration in the development of such construction bores is not so much the ability of the groundwater reservoir to withstand the total withdrawal, but rather the finding of

* In that region many engines pump continuously for two days per week at about 2.25 *l*/s (2000 gph), i.e. they withdraw 22 700 m^3 per year.

an aquifer with sufficient transmissivity to permit the peak withdrawal rate; or if such an aquifer cannot be found, whether a lesser one can be economically used by providing surface storage or additional bores.

The situation with town water supplies is rather similar. If a consumption of 460 *l* per day per person is assumed, a town bore serving 50 people withdraws 8400 m^3 per year, which is less than most pastoral bores withdraw; on the other hand, the withdrawal by town bores is a permanent feature of the groundwater budget. Although overdevelopment is locally possible, particularly in agricultural areas, it is not regionally important at this stage.

Collection and reliability of data

The known hydrological data on over 500 water bores are presented in Appendix 1. The information has come from drillers' logs recorded in station records and in the files of the Water Resources Branch of the Northern Territory Administration. Many of the bore logs are incomplete, and for some bores no information can be found. Also, some records refer to bores which can no longer be located on the ground. Most of the logs record the depth of the bore, but less than half record the depths of the various aquifers; a little more than half record the depth of the standing water level. About three-quarters of the logs record the supply, but commonly the figure is an estimate only or is at the limit of the equipment used to test the bore on completion. Despite the limitations of the bore logs, it has been possible to identify with reasonable certainty the producing rock unit for about three-quarters of the bores. This aspect is discussed in some detail in the section on aquifers (p. 47).

The information obtained from the records was usefully supplemented by scouthole drilling by the Bureau of Mineral Resources in 1965 and 1966; of 22 holes drilled, nine obtained water. Data on these bores are presented in Appendix 4. Several construction and pastoral bores were also drilled and completed during the 1966 survey and the author was able to obtain at first hand the relevant data from them.

Surface elevations have been obtained by barometric traverses tied to a network of third order instrument-levelled benchmarks erected by the Department of the Interior. The benchmarks are along most of the major and secondary roads, and some—from Wave Hill to Powell Creek—are across country. The barometric traverses were carried out concurrently with the helicopter gravity survey, during which stations were sited at a density of approximately one per 50 square miles (one per 130 km^2), i.e. on a 7-mile (11-km) grid. Additional carborne barometric traverses were carried out during the 1965 and 1966 geological surveys. The contours shown on Plate 1 have been obtained from the barometric and instrument-levelled heights; the elevations and their positions are shown on the first edition and preliminary geological maps of most of the 1:250 000 Sheet areas within this region. The elevations of the bores are listed in Appendix 1.

Bore waters for analysis were collected in 1965 and 1966 under the same general conditions as those outlined by Randal (1967, p. 34); 168 samples were analysed by the Australian Mineral Development Laboratories in Adelaide (AMDL). The concentration of the major anions and cations and of several trace constituents were determined, as well as total dissolved solids (TDS), specific conductivity (S.C.) and pH. An additional 42 analyses were obtained from station records and files, but some are incomplete or suspect; the latter are analyses which show a gross anion-cation imbalance although values for all major anions and cations were reported. They cannot be used for classifying the groundwater type, nor can they safely be used for calculating ionic ratios, but the determined total dissolved solids can be regarded as a reasonable estimate of the salinity. The chemical analyses are presented in Appendices 2 and 3. Chemical analyses were also obtained for samples from several of the BMR scoutholes and these are presented in Appendices 5 and 6.

OCCURRENCE

Aquifers

Groundwater is available throughout the region at various depths from aquifers ranging in age from Precambrian to Tertiary (Fig. 8). However, the degree of availability varies markedly, as the occurrence of groundwater is strongly controlled by the variations in rock types, their physical properties, and the structure. In areas of volcanics, failures and poor supplies are numerous, whereas elsewhere good supplies are virtually assured at any site selected. The density of bores in many areas, particularly in the central south, is extremely low, and hence few inferences can be made about the groundwater regime in large parts of the region. The occurrence of flat-lying Mesozoic rocks over the northern and northeastern part of the Main Plateau has a marked effect on the depth to aquifers; the Mesozoic rocks generally are poor prospects and hence aquifers in the underlying sequences have a considerable overburden of unproductive rocks.

Precambrian aquifers

Groundwater has been obtained in various amounts from most of the Precambrian sequences in the region, but only the Tomkinson Creek Beds and, briefly, the Victoria River Group will be considered in this Bulletin.

The *Tomkinson Creek Beds* form the strike ridges and dissected plateaux of the Ashburton Range and Whittington Range; because the ranges are generally inferior grazing land and also contain some large waterholes, the unit contains far fewer bores than the others. Many bores within the ranges are shallow, drawing supplies from outliers of younger rocks.

Several bores on Banka Banka station obtained supplies from the Tomkinson Creek Beds, notably Nos 14, 15, and 16, and the Homestead Bore. Nos 14 and 16 have been abandoned because of failing supply and poor-quality water. Generally the bore logs support the inferences drawn from the evidence of wells and springs that groundwater is available at shallow depths. Bores commenced in the Tomkinson Creek Beds have obtained supplies at depths less than 34 m; others have drilled through unproductive Cambrian sediments and have obtained water in the older rocks at depths between 60 and 90 m. An exception is Muckety No. 1, which, although begun in the Tomkinson Creek Beds, was drilled to 220 ft (68 m) before water was obtained. The standing water level, however, indicates that the groundwater regime is shallow.

In the northern and central parts of the Ashburton Range conditions are different. Newcastle Waters station Bore and two bores at the township obtained mediocre supplies, apparently in Tomkinson Creek Beds, at depths of about 53 m, and the water rose a metre or so. One of the township bores was deepened to over

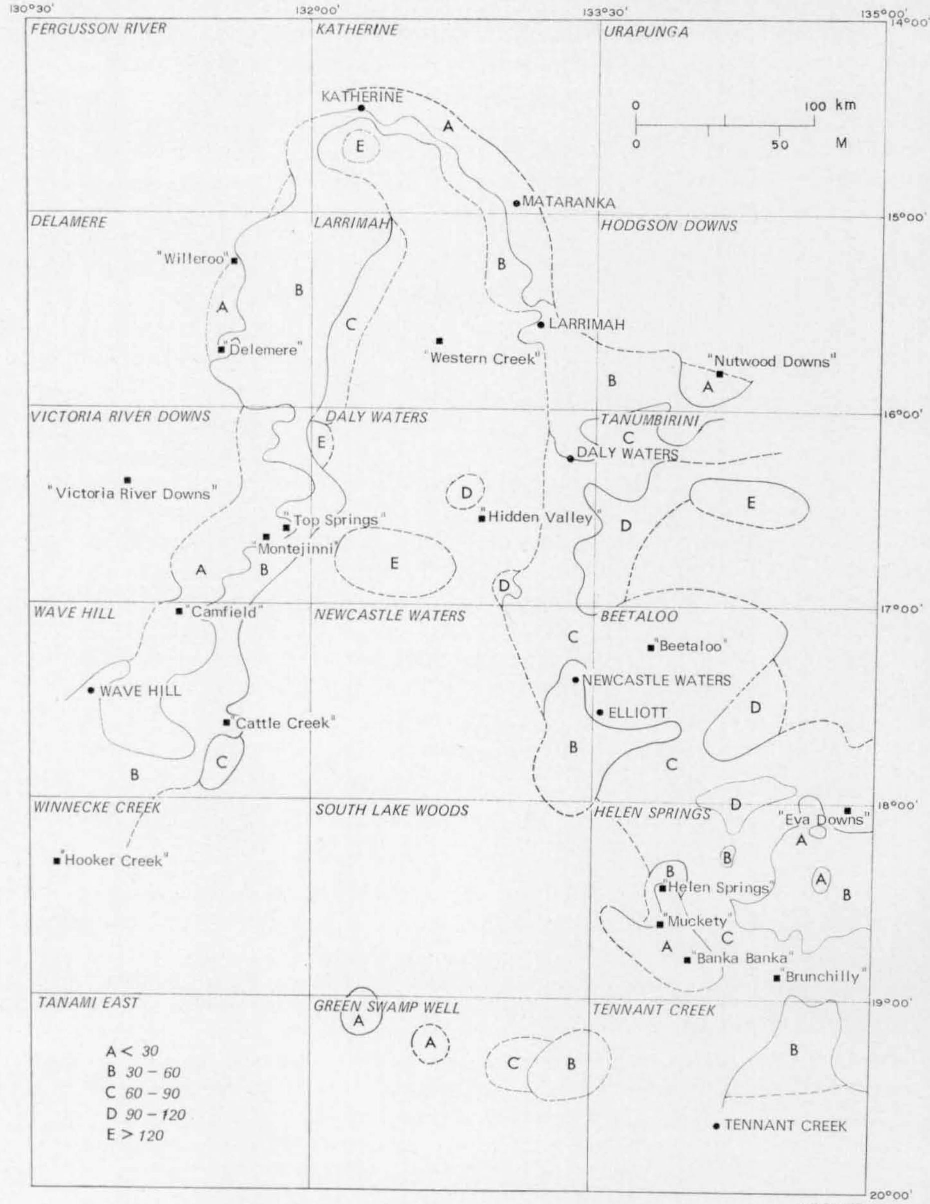

Fig. 8. Depth to groundwater in the region.

90 m with no improvement in the supply. In the central part of the range at Renner Springs, a stock route bore was drilled to below 155 m, but only a small supply of brackish water was obtained, at 20 m.

Drillers' logs of bores in the Tomkinson Creek Beds are inadequate for determining the essential geological control of groundwater occurrence, and an appraisal can only be made on the basis of rock types and structure as evident from outcrop. Although the Tomkinson Creek Beds contain considerable amounts of sandstone, the permeability and storage characteristics of the unit are probably controlled by fracturing; most sandstones have an argillaceous or siliceous cement which has effectively reduced their porosity. The rocks are tough and hard and are difficult to drill. The aquifer system is not a regional one, mainly because the continuity of aquifers has been broken by folding and block faulting. Probably the groundwater regime consists of small independent basins with local recharge areas and fairly shallow potentiometric surfaces. The depth to water is probably largely controlled by the tightness of joints and of fractures along fault zones and fold axes. Except along the crests of anticlines and in fault zones, fewer openings can be expected at depth, and secondary silicification may severely restrict storage.

Although carbonate (mainly dolomite) and leached carbonate rocks are known in the sequence they are probably neither thick enough nor sufficiently continuous for extensive cavities and fissure openings to have formed. However, heavily weathered carbonate rocks close to local recharge areas may provide small supplies. A possible example is Ladabah Bore on the floodout of Tomkinson Creek; the driller's log records 700 gph (0.88 *l*/s) from 70 ft (22m) in limestone beneath sand and clay. Probably the highest potential for the unit is in the development of shallow bores along major faults and lineaments: Banka Banka homestead Bore, from which 1.9 *l*/s (1500 gph) are obtained from several aquifers between 4 and 22 m in rocks described as hard sandstone and quartzite, is alongside a zone of major faulting.

Because of the probable shallow groundwater conditions, geomorphological situations may markedly influence the groundwater storage. Bore sites along major streams and in alluviated plains bounded by elevated country and with constricted outlets for the surface drainage may be productive, though the latter type in this arid climate may produce salty water.

Although most bores that withdraw water from the *Victoria River Group* occur to the west of this region, the unit is important because within the region it underlies the Antrim Plateau Volcanics. A number of bores have been drilled through apparently unproductive volcanics to tap water in the older rocks. Hooker Creek No. 8 is an example; it was drilled to 330 ft (102 m) through 180 ft (56 m) of basalt and 120 ft (37 m) of alternating shale, basalt, and limestone overlying a limestone/sandstone sequence. Mediocre supplies were obtained at 106 and 123 ft (33 and 38 m), and on further drilling a supply of 2.5 *l*/s (2000 gph) was obtained at 317 ft (98 m) from rocks of the Victoria River Group.

Similarly, bores on Wave Hill, Delamere, and Victoria River Downs have successfully obtained water in the older rocks beneath the basalt. Wave Hill WR Bore began in basalt and penetrated 205 ft (64 m) of unproductive volcanics before entering sediments of the Victoria River Group from which it obtained 2.05 *l*/s (1650 gph) at 285 ft (88 m). No. 48 Bore on the Wave Hill Stock Route obtained mediocre supplies at 32 ft (10 m), and also at 232 ft (72 m), the base of the basalt. Below this, the bore penetrated sediments of the Victoria River Group and obtained water at 250 ft (78 m), but the main supply came from 321 ft (100 m). Two bores on Camfield station, Homestead Bore and Rara Bore, obtain supplies from sandstone beneath the basalt. At the Homestead Bore particularly, the thickness of sandstone penetrated beneath the basalt is many times that of the sedimentary beds normally encountered within the basalt, and its description, 'hard and soft sandstone—mainly pink', is more aptly applied to sandstone of the Victoria River Group, but the evidence is not conclusive.

On the other hand drilling through the basalt to obtain water from the Victoria River Group may not be economic: the basalt is extremely difficult to drill and in some areas is several hundred metres thick. Furthermore the results of drilling below it may be disappointing. Wave Hill No. 24 Bore was drilled to 744 ft (231 m) in an area west of the homestead where the volcanics are about 100 m thick; it was unsuccessful. WS Bore, 6 km south of the homestead, penetrated 167 ft (50 m) of basalt and continued unsuccessfully to 900 ft (270 m) in the Victoria River Group. WQ Bore obtained 0.13 *l*/s (100 gpm) at the base of superficial deposits over basalt, at 0.5 *l*/s (400 gph) at 327 ft (101 m) in the basalt, and 4.5 *l*/s (3600 gph) in the Victoria River Group, but was abandoned because of high salinity.

Similarly one of the test bores for the new Wave Hill homestead site was drilled 1144 ft (355 m) into the Victoria River Group, and at 1025 ft (318 m) obtained a mere 0.23 *l*/s (180 gph) of water containing nearly 2000 ppm of chloride ion. Hays (*in* Barcley & Hays, 1965) investigated the groundwater associated with the Victoria River Group on Victoria River Downs station and his observations are pertinent to this Bulletin: 'Not only are arenaceous beds beneath the basalt better producers than argillaceous rocks in similar positions but also in the arenaceous beds the availability of water is dependent more on open bedding-planes and points than on grainsize'. Hays also highlights the importance of bore position in relation to recharge areas. He noted that bores down-dip from the probable main recharge area had high yields, but yields of those up-dip from the recharge area were low.

Lower Cambrian aquifers

Lower Cambrian volcanic sequences provide groundwater in the western, northeastern, and southeastern parts of the region. ND Bore on Nutwood Downs station obtains 2.5 *l/s* (2000 gph) from an unknown aquifer which may be the Lower Cambrian Bukalara Sandstone beneath the Nutwood Downs Volcanics.

The *Antrim Plateau Volcanics* in the western part of the region contain aquifers in a large area from Hooker Creek settlement in the south to beyond Willeroo homestead in the north, but the unfavourable hydrogeological conditions in the unit have resulted in a high percentage of unsuccessful bores. As indicated in Figures 8 and 16, the groundwater regime is essentially shallow. Most aquifers are less than 60 m and many less than 30 m below ground surface. Also, the potentiometric surface is generally less than 30 m below ground surface, and in many areas less than 15 m, particularly on Wave Hill and Camfield stations and large parts of Killarney and Delamere stations.

Bores deeper than 30 m drawing supplies from the Antrim Plateau Volcanics appear to fall into three main categories. The first is in the northwestern part of the Main Plateau, where locally the Middle Cambrian and younger rocks either are above the water table or do not contain exploitable aquifers. The combined thicknesses of the younger units necessitate a substantial amount of non-productive drilling before the aquifers in the Volcanics are reached. In bores of this category the standing water level may or may not be above the disconformity at the top of the Volcanics. The second category is that of bores positioned on basalt plains at considerable heights above the main local recharge areas, the valleys of the major watercourses. These bores are readily identified from Plate 1 and Appendix 1; they commence in the Volcanics and both the depth to water and the standing water level are well below ground level. Both these possibilities can be readily recognized when future bore sites are sought and can be either accepted or avoided as the circumstances determine.

The possibility of the third category, in which the chances of fissure intersection and hence supply are increased with greater penetration of the basalt, is rather more difficult to assess with present knowledge. Obtaining water from the volcanics is largely dependent on the intersection of open bedding planes, joints, and fractures not only sufficiently large and interconnected to contain and transmit water, but also beneath the water table. As stated earlier this happens at fairly shallow depths over much of the outcrop area of the Volcanics. That it is not inevitable is shown by the number of abandoned holes on Wave Hill station, in particular those near the homestead. Table 6 shows that too early cessation of drilling was not necessarily responsible for the failures.

TABLE 6. BORES AT WAVE HILL
(All bores solely in basalt)

Regd No.	*Depth* *m*	*Standing water level* *m*	*Supply* *l/s*
818	18.9	9	0.4
819	66.8	8	0.4
820	14	9	1.1
846	18	—	dry
847	18	—	dry
848	20	—	0.05-0.2

1 gph = 0.00126 *l*/s
1 gph/ft = 0.00414 *l*/s/m

Clearly the watertable at the homestead is at a shallow depth, and even allowing for small differences in elevation at the sites, all bores penetrated it. No. 820 Bore obviously intersected a zone of highly fractured rocks with high transmissivity, but the results of Nos 818 and 819 Bores suggest less fracturing. The results of the other three holes indicate the formation was extremely tight. Although the records of No. 819 Bore are not sufficiently specific, they do suggest that the openings in the rock are fewer at depth and that supply was not increased by drilling a deep hole.

To some extent the results of this hole justified the pastoralist's reluctance to drill the last three holes to a greater depth. On the other hand the chance of intersecting many openings obviously increases with depth of penetration, but there must be a depth where this advantage is lost as the joints become tight. Figure 9 illustrates the greatly improved supply which resulted from deepening eight bores, which began and finished in the Volcanics. Most bores in this category are in the northern part of the outcrop area of the Volcanics, but the conditions cannot be related to geographical position. The bore records are generally not detailed enough to exclude its possible occurrence in the southern part. Furthermore, there are instances in the north in which the deepening of bores was not successful: a bore a few kilometres south of Killarney homestead obtained 0.19 *l*/s (150 gph) at 38 ft (12 m) and was drilled to 593 ft (184 m) without improving the supply.

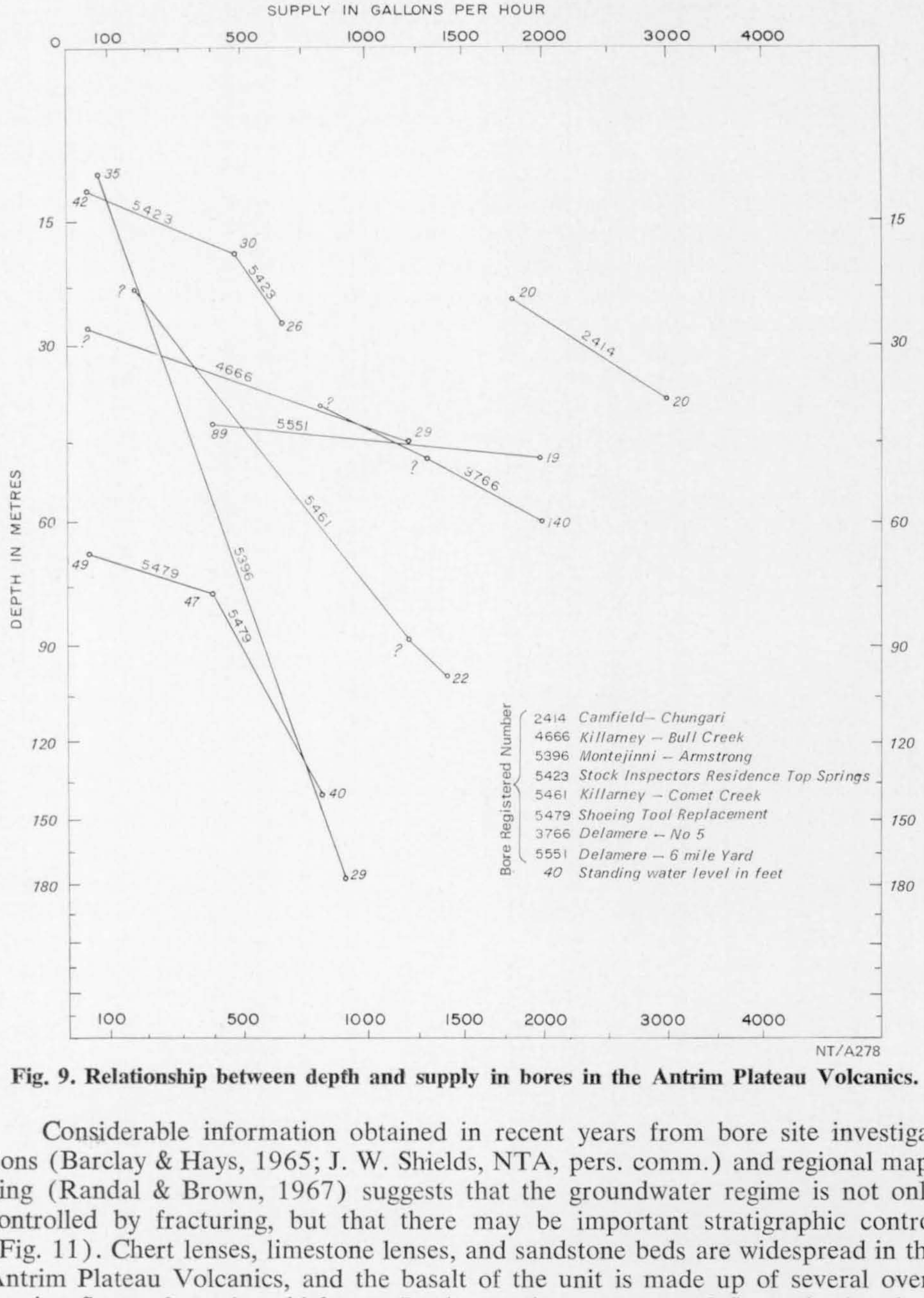

Fig. 9. Relationship between depth and supply in bores in the Antrim Plateau Volcanics.

Considerable information obtained in recent years from bore site investigations (Barclay & Hays, 1965; J. W. Shields, NTA, pers. comm.) and regional mapping (Randal & Brown, 1967) suggests that the groundwater regime is not only controlled by fracturing, but that there may be important stratigraphic control (Fig. 11). Chert lenses, limestone lenses, and sandstone beds are widespread in the Antrim Plateau Volcanics, and the basalt of the unit is made up of several overlapping flows of varying thickness. In the contiguous zones of flows the basalt is vesicular, ashy, brecciated. The chert lenses are commonly brecciated and contain large vugs. Both the chert and limestone are jointed, and, though massive in outcrop, are laminated and contain widely spaced open bedding planes. They would be aquifers where suitably situated, although their transmissivity would have a wide range. The physical characteristics of the sandstones are ideal for containing and transmitting water. However, the part immediately underlying the basalt is

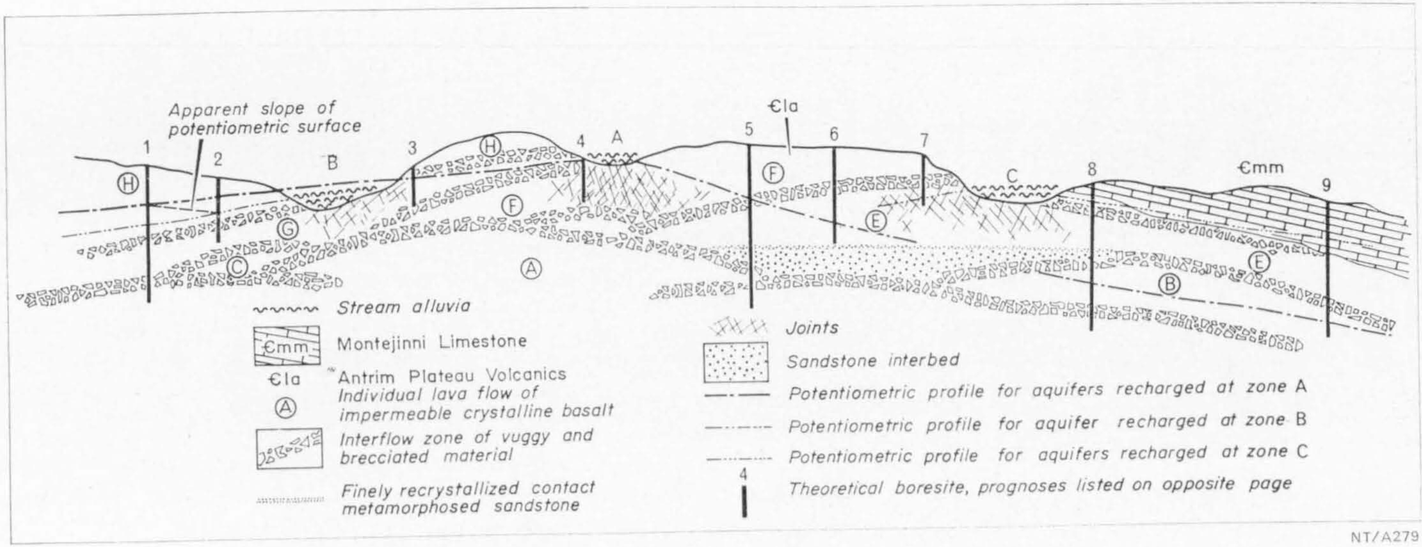

Fig. 10. Groundwater regime of the Antrim Plateau Volcanics.

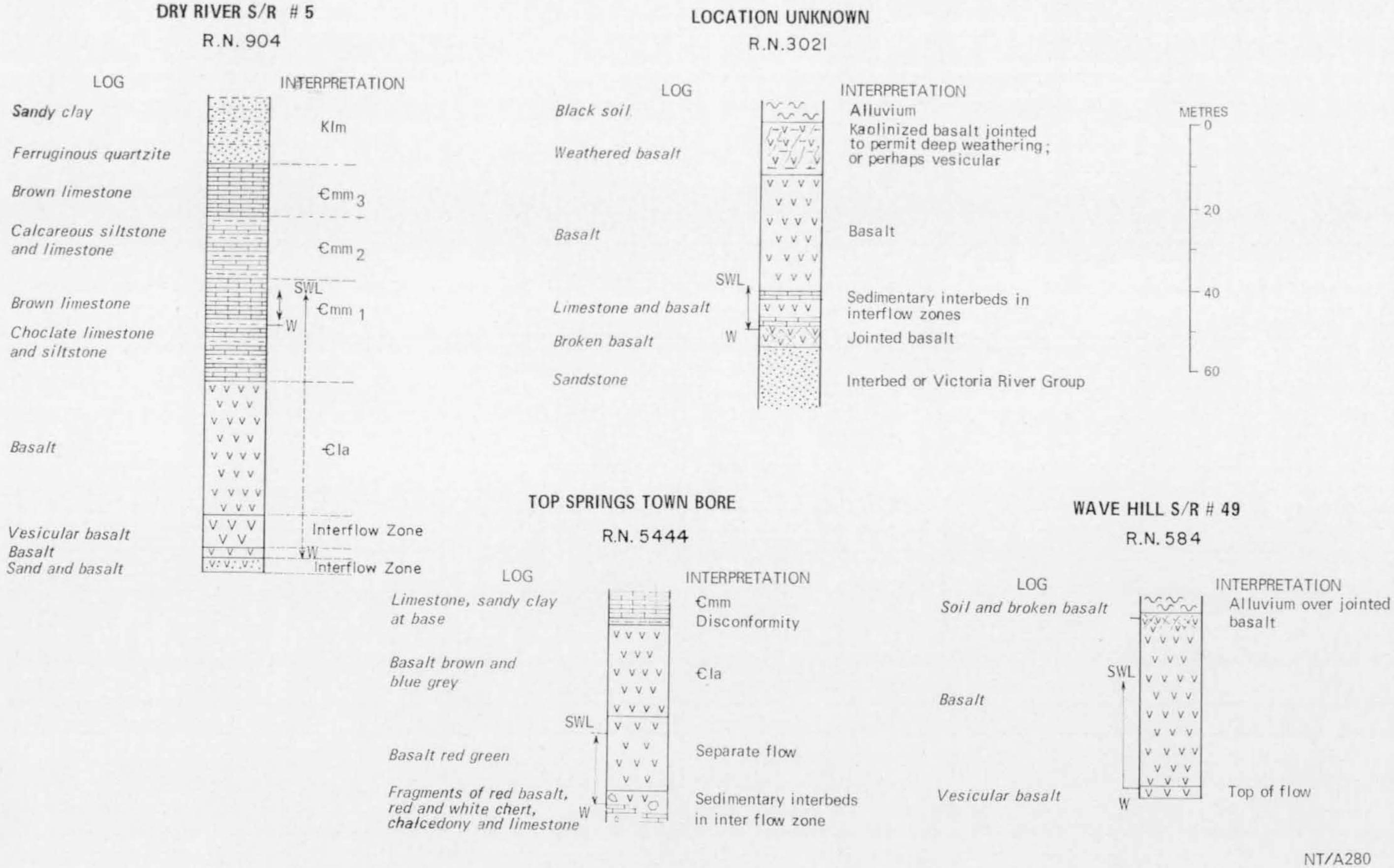

Fig. 11. Interpretation of logs of waterbores in the Antrim Plateau Volcanics.

indurated and recrystallized to a tightly bonded rock with a low permeability; it must be broken by joint systems before the sandstone can receive recharge. The sandstone beds are jointed to various degrees.

The basalt in the interior of the flows is well crystallized and compact and has a low permeability. Hence, the zone between successive flows may act as a confined aquifer, which, depending on the areal dimensions of the flow, may be of local or regional extent. Similarly the interbedded sediments may constitute local or regional confined aquifers. A standing water level higher than the level of unconfined water in the same bore certainly suggests recharge from different sources. These aspects are discussed further in the section on hydrodynamics. Figure 10 illustrates different situations of the groundwater regime in the Volcanics. Figure 11 shows typical interpretations of water-bore logs.

Although the disconformity between the Antrim Plateau Volcanics and the Middle Cambrian carbonate rocks is not necessarily at the top of a flow, it has in places an associated zone which is highly permeable owing to ancient weathering and the accumulation of debris which is now partially compacted and forms the basal metre or so of the carbonate sequence. Several bores obtain their main supplies from this zone (see RN 4807, Fig. 13).

The results of water-bore drilling in the Lower Cambrian *Nutwood Downs Volcanics,* a probable correlate of the Antrim Plateau Volcanics, have been extremely disappointing. Although the sequence contains lavas with interbedded sediments, several holes drilled into it were unsuccessful. Three were abandoned owing to hard drilling in the volcanic rocks. Nutwood Downs Nos 2, 8, and NA Bores obtained reasonable supplies in sandstone, but the regional geology suggests that the aquifers may be in the Precambrian Roper Group. Bore ND obtained 2.5 *l*/s (2000 gph) in sandstone underlying 340 ft (105 m) of basalt. This may be a bed within the Volcanics, but the regional geology suggests that it is more likely to be the Bukalara Sandstone. The drill terminated in the Sandstone after penetrating 25 ft (8 m).

The *Helen Springs Volcanics,* also a correlate of the Antrim Plateau Volcanics, have been successfully drilled both within and on the flanks of the Ashburton Range. Groundwater is contained in joints, faults, and porous zones in vesicular and ashy lavas, as in the Antrim Plateau Volcanics.

The proportion of interbedded sedimentary rocks is not as high as in the Antrim Plateau Volcanics, but a friable and jointed sandstone member at the base of the sequence is extremely porous and permeable and, wherever it is beneath the watertable, yields ample supplies of water. The bore records are not sufficiently detailed to evaluate the relative abundance of the various hydrogeological situations within this unit. The volcanic rocks are deeply weathered and lateritized; the importance of these effects on supply and recharge is discussed later.

Middle Cambrian aquifers

Groundwater is obtained from Middle Cambrian rocks over most of the Main Plateau, and in the terraces on its western flanks. Middle Cambrian rocks also contain groundwater in the Daly River Basin to the north of the Plateau. The main producing formations are the Tindall Limestone in the Daly River Basin and in the northern environs of the Barkly Tableland, the Montejinni Limestone in the central western part of the Plateau, the Anthony Lagoon Beds in the Barkly Tableland,

and the Merrina Beds in the central southern part of the Plateau. It is not known if any producing bores obtain groundwater from the Gum Ridge Formation, which crops out in the Barkly Tableland and the Ashburton Range, but a bore on the South Barkly Stock Route yielded on test 1.25 *l*/s (1000 gph) from rocks believed to be part of that formation. The Middle Cambrian units are mainly carbonate sequences and most of the producing bores obtain water from cavities, joints, and fissures in them, although interbedded sandstone and siltstone may be important hydrogeologically. Groundwater is also produced from the unconformity with underlying units and also from the unconformity with the overlying Mullaman Beds.

The *Tindall Limestone* is a massive, well jointed limestone containing dolomitic patches and beds, which crops out as fluted karst pinnacles and blocks with large open bedding planes. It is extremely cavernous. It is commonly a mottled two-tone limestone; in exposures in watercourses the lighter material (coarser recrystallized calcite) has been dissolved, producing a honeycombed rock with high storage capacity. The unit is the main producing aquifer in the southern part of the Daly River Basin, along the country bordering the Stuart Highway as far south as Daly Waters, and in the northern environs of the Barkly Tableland between the headwaters of the Hodgson River and the Daly Waters/Borroloola Road. The drillers' and geologists' logs of the water bores suggest that the groundwater occurs in the unit in a variety of ways (Fig. 12). Although no stratigraphically controlled regional aquifer has been recognized within the unit there is evidence that lithological control is important at least locally. Bore CCA on the Daly Waters/Borroloola Road obtained water at the junction between siltstone and underlying limestone, and Bore CCC, 32 km to the east, obtains its supply from a calcarenite bed between beds of calcilutite (see Fig. 12).

Many of the bores in the Katherine area obtain water from beds with texture or composition different from that of the enclosing rocks. But the main control on the groundwater regime is the occurrence of joints, fractures, cavities, and debris within the large cavities (Fig. 12). A bore on the Katherine Showground obtained good supplies at 78 and 80 ft (24 and 25 m) after entering a cavity at 76 ft (23½ m), and Birdum Stock Route No. 5 Bore obtains water from a zone described by the driller as 'broken limestone and caves'. The producing zone of Birdum Stock Route No. 1 Bore has been described as 'limestone gravel and buff clay' and for an old army bore north of Gorry as 'medium gravel limestone and quartz pebbles'; this type of zone is interpreted as a sink-hole filled by weathered or collapsed debris.

The groundwater regime of the Tindall Limestone in its outcrop areas is essentially a shallow one. On the northern flanks of the Main Plateau, aquifers in this unit are generally less than 30 m deep and the potentiometric surface is correspondingly shallow. The groundwater normally is confined even in the shallow zone. Farther south the depth to the groundwater increases markedly because of the flat-lying, normally unproductive Lower Cretaceous rocks which overlie the limestone. Good water-producing zones may occur at the unconformity between the units, but if not, experience shows that the Tindall Limestone needs to be penetrated usually for the best part of 30 m before adequate supplies are obtained. The effects of the Lower Cretaceous rocks are discussed under aquifers of that age.

The *Montejinni Limestone* is the main producing aquifer in the western part of the main plateau and on its immediate western flanks. As discussed earlier

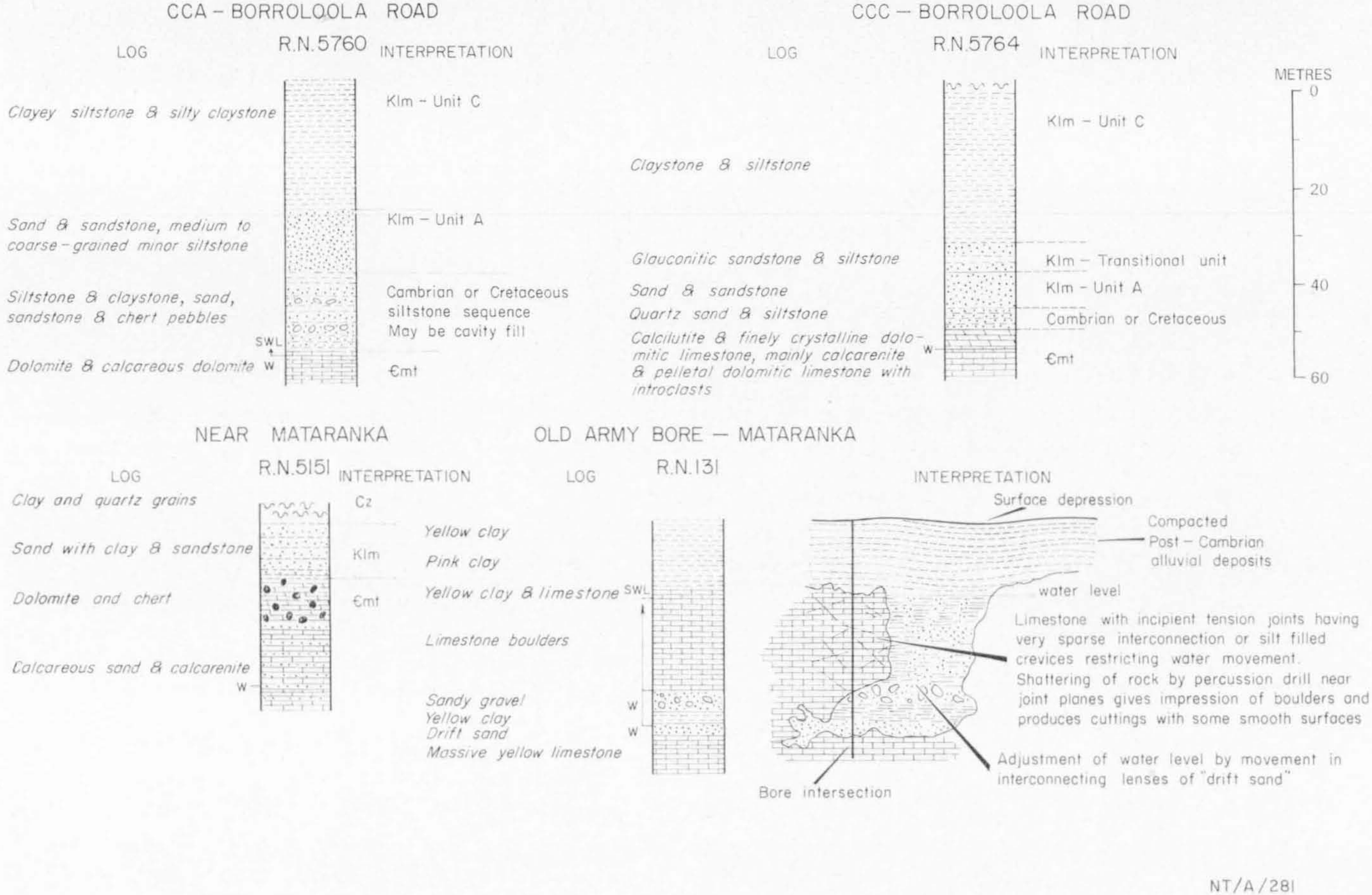

Fig. 12. Interpretation of logs of waterbores in the Tindall Limestone.

(p. 24) this unit is in part a correlate of the Tindall Limestone and it is not known precisely how far eastward it extends. Hence aquifers referred to the Tindall Limestone in the central part of the region may actually be within the Montejinni Limestone.

The occurrence of groundwater in the Montejinni Limestone is controlled by features similar to those in the Tindall Limestone, viz. joints, fissures, cavities, and some lithological control (Fig. 13). Probably strong regional effects are caused by the middle mudstone unit within the formation, but the drillers' logs are not specific enough to identify them. Present knowledge suggests that most water is available from the bottom unit, reasonable supplies from the middle units, and little from the upper unit of the formation. However, as the formation is flat-lying or nearly so, this observation may merely reflect the relative positions of the units to the watertable.

Clearly the highest stratigraphic unit of the generally flat-lying formation is the least likely to be below the watertable, particularly where the unit crops out. Monster Bore on Killarney station (Fig. 13) began in the upper limestone unit of the formation and obtained water near the base of the middle mudstone unit, but the main supply came from the underlying basalt. Dry River Stock Route No. 5 Bore began in Lower Cretaceous sediments and penetrated all three units of the Montejinni Limestone. It obtained an unknown supply at 182 ft (56 m) in the lower limestone unit, but was deepened and also obtained its main supply from the underlying volcanics (Fig. 11) Birrimba homestead Bore began in the upper unit and drilled through the middle unit into the lower one, obtaining its supply near the base of the middle unit (see Fig. 13). Dry River Stock Route No. 9 Bore (Charlies Hole) began in the lower unit and obtains an excellent supply at 73 ft (23 m). A bore drilled along the new road alignment from Willeroo to Top Springs (RN 5578) began in Lower Cretaceous rocks and obtained its main supply at the base of the upper unit of the Montejinni Limestone. Bauhinia Bore on Killarney station began in the upper unit and the log records an aquifer at 29 ft (9 m), although the hole is 19 m deep; if no other aquifer was encountered below 9 m then the main supply is the upper unit. Although the driller's log records only limestone this hole would certainly have intersected the middle mudstone unit between 12 and 16 m as mudstone crops out in a gully a few kilometres to the south.

The *Anthony Lagoon Beds* contain the prolific aquifers of the central and western Barkly Tableland (Randal, 1967) and its northern environs. As discussed in the chapter on geology this unit and the Tindall Limestone are in part correlates. Although the cuttings from bores along the western part of the Cape Crawford Road are recognizably Tindall Limestone, cuttings from those along the eastern part more closely resemble the rock types of the Anthony Lagoon Beds. It appears that bores that penetrated the Lower Cretaceous rocks without obtaining water in the Beetaloo Sheet area to the south of this road are obtaining supplies from the Anthony Lagoon Beds.

Generally the groundwater regime of the Anthony Lagoon Beds is considerably deeper than that of the Tindall and Montejinni Limestone. Over much of the outcrop area of the unit, bores must be drilled 60 to 90 m before encountering adequate supplies of groundwater, and the depth to the potentiometric surface is correspondingly greater than for the Tindall and Montejinni Limestones. However, about the northern extension of Attack Creek and eastward from it, groundwater

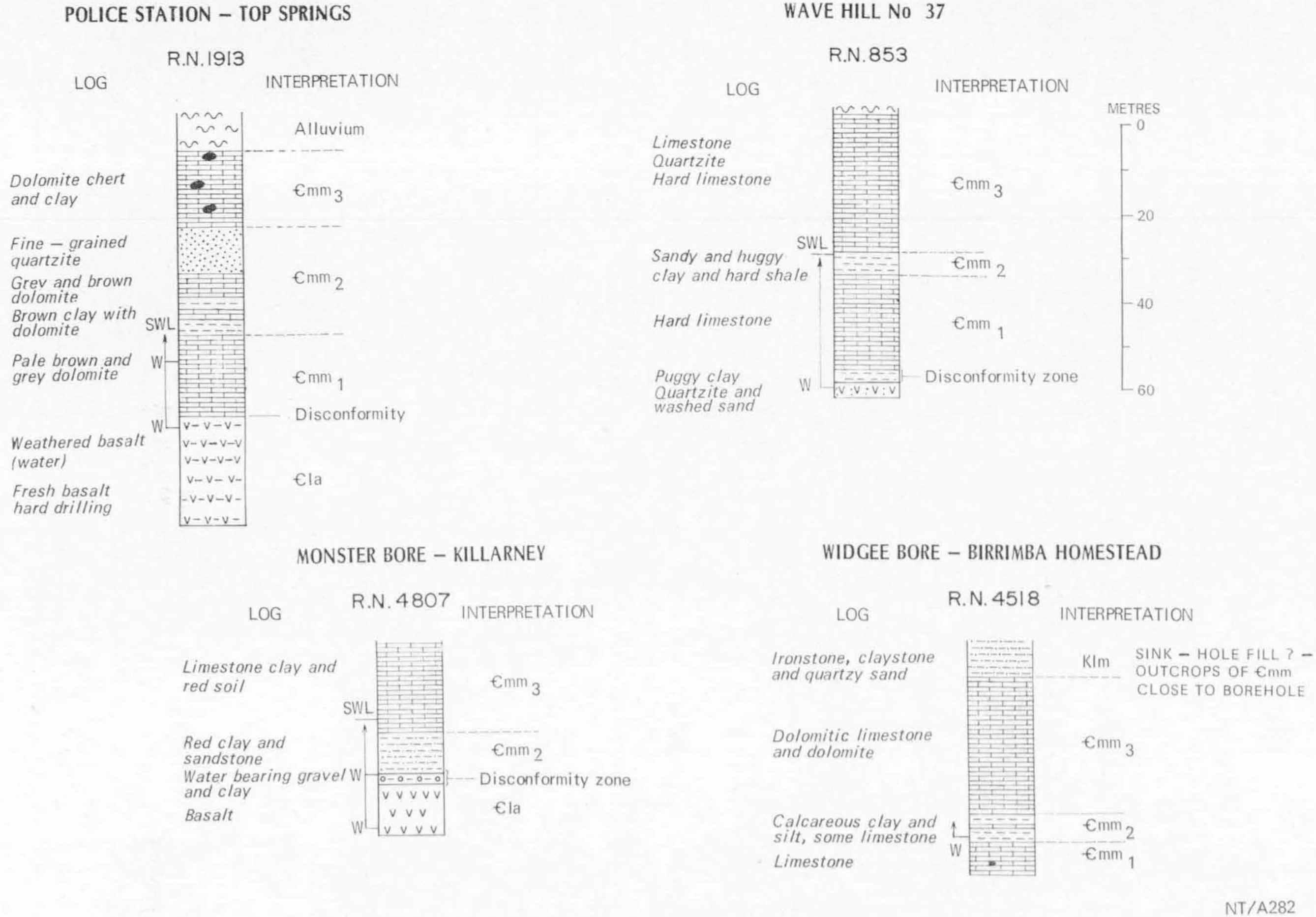

Fig. 13. Interpretation of logs of waterbores in the Montejinni Limestone.

is usually obtained less than 60 m below ground level. The lesser depth to groundwater is presumably related to the topographic depression which contains the flood-out areas of Attack Creek (northern extension), Brunchilly Creek, and the south-flowing creeks which rise to the north of Eva Downs homestead. Another area of shallow groundwater occurs to the east on the Brunette Downs Sheet area.

Much evidence for the general groundwater environment in the Anthony Lagoon Beds has come from the eastern part of the Barkly Tableland, where the unit is the main groundwater producer (Randal, 1967). In the western part there is very little coherent and unaltered outcrop of the unit, so it is difficult to assess the hydrogeologically important physical characteristics of the rocks. Furthermore, drillers' logs of bores in the western part of the tableland are few and grossly misleading. However additional information was obtained from a few scoutholes drilled by the Bureau of Mineral Resources in 1965. The occurrence of groundwater in the unit is, as in the other carbonate formations, controlled by cavities, joints, and zones of fracturing, but there is some evidence of strong lithological control; the groundwater is normally confined.

Cuttings from some water bores and from the scoutholes indicate more sandstone and siltstone beds in the carbonate sequence than is apparent from surface mapping. Some of these beds, particularly the sandstones, would be good aquifers wherever they occur beneath the watertable. The sandstones, though fine-grained, are clean and well sorted, and commonly are porous and friable. Variations in texture of the carbonate rocks also are important. In Scouthole B1 dolomite and limestone both had a pelletal texture, but whereas the pore spaces were incompletely filled in the dolomite, they were completely filled with calcite cement in the limestone. Sandy limestone with various textures has also been recorded from the scoutholes. Both the dolomite and the limestone contain vugs, which are more widespread in the dolomite or dolomitic rocks.

In the central and southern parts of the Main Plateau west of the Ashburton Range groundwater is available from the *Merrina Beds,* but only in the central part of the Wiso Basin (along the line of scoutholes in the Green Swamp Well Sheet area) can the aquifer be referred unequivocally to this unit. The Merrina Beds, as discussed in the section on geology, may extend as far north as the Murranji Track and eastward to about Lake Woods, but the description of strata in the bore logs is generally not specific enough to prove this extension. In most there is no clearly defined boundary between the Lower Cretaceous sediments and the underlying units; neither is there always a clear distinction between the various Middle Cambrian units.

The driller's log for Bradman Bore refers to 'limestone clay, yellow limestone, clay and boulders' down to 137 ft (43 m), yet the bore lies in an area covered by rubble of Lower Cretaceous rocks. There is conclusive evidence from drillers' logs in other parts of the region that the compacted Cretaceous mudstones are frequently recorded as limestone. The description of 'very hard limestone, quartz, and ribbonstone' in the log for Benaud Bore on Newcastle Waters can be readily interpreted as a chert-bearing dolomite, which is more likely to be in the Merrina Beds than any other formation, especially as rare outcrops of dolomite occur in the region. But the sequential description 'yellow limestone, red clay, limestone and gravel with water' from the log of No. 12 Murranji Stock Route could equally well refer to the Montejinni Limestone.

Because the line of scoutholes in the Green Swamp Well Sheet area is so far from the areas of high bore density, and because of the consequent lack of control points in such a large area, it is extremely difficult to relate the groundwater regime of the Merrina Beds to that of the region as a whole. The data in Appendix 4 indicate that the depth to aquifers differs greatly from hole to hole, but to some extent this is caused by the undulating terrain. Similarly, the depth to the potentiometric surface is extremely variable, but the surface is between 225 and 243 m above sea level. GSW 1 and GSW 2 obtained reasonable supplies of water from the vuggy dolomite and dolomitic rocks in the lower part of the Merrina Beds, whereas GSW 5 and probably GSW 4 obtain groundwater from friable sandstone in the upper part of the sequence.

The holes in the Winnecke Creek and Tanami Sheet areas all began in the sequence of siltstone and claystone with interbedded dolomite that occurs in the middle part of the Merrina Beds. All except WC 3, which was the shallowest, penetrated the basal dolomitic section to various depths. But only TE 1 and WC 2 encountered water and then only as minor seepages. It appears that the middle parts of the sequence are either above the potentiometric surface or are too tight and impermeable to be useful aquifers. Consequently in the western parts of the Wiso Basin it may be necessary to drill holes deep enough to encounter the vuggy dolomite below the watertable.

The *Gum Ridge Formation* is not definitely known to be a producing aquifer; bores on the eastern environs of the Ashburton Range whose supplies are attributed to the Anthony Lagoon Beds may actually be obtaining water from the Gum Ridge Formation. Scouthole HS 6 began in surface outcrop of the formation and obtained a good supply from the disconformity with the underlying Helen Springs Volcanics at 66 ft (21 m). The water rose 6 m in the hole, indicating that part of the younger formation is beneath the potentiometric surface and wherever permeable should provide water. However, the upper exposed parts of the formation are extremely silicified or weathered claystones and very fine siltstones with low permeability. Within the ranges the outliers of the formation are thin erosional remnants and are well above the potentiometric surface. However, Bore No. 12 on the South Barkly Stock Route obtained on test 1.25 *l*/s (1000 gph) from aquifers between 280 and 309 ft (87 to 96 m) in fossiliferous limestone referred to the Gum Ridge Formation or its probable correlate the Anthony Lagoon Beds.

Other Palaeozoic aquifers

Scouthole K1, 64 km south of Katherine, intersected several aquifers in the *Jinduckin Formation,* of Cambrian/Ordovician age. Aquifers encountered in bore holes west of Katherine have been attributed to the *Manbulloo Limestone Member* of this formation. Although there is some evidence that the formation occurs subsurface about Larrimah it appears to be either too thin or above the watertable and hence is not regarded as a potential aquifer there. In Scouthole K1 all the aquifers were in beds of dolomite (Manbulloo Limestone Member?) which owed their porosity and permeability to vugs and intergranular and intercrystal porosity. Sandstone occurred in the hole above 25 m and hence above the watertable, whereas the non-carbonate rocks below 25 m were impermeable siltstones. The upper aquifer, between 100 and 105 ft (31 and 33 m), was a perched and unconfined one; the remaining aquifers (below 68 m) all had a standing water level of about 56 m. The sandstone is fine-grained, well sorted, and porous, and should be a reasonably good aquifer at depth; perhaps it would be below the regional watertable farther northwards in the central parts of the Daly Basin. The Scotts Creek Bore in the Fergusson River Sheet area obtained good supplies from numerous shallow aquifers described as interbedded shale and porous and vuggy calcilutite. Several bores obtained shallow groundwater in the vicinity of Manbulloo homestead and Manbulloo aerodrome and presumably intersected aquifers in the Manbulloo Limestone Member. One bore reputedly flowed after reaching an aquifer at 28 m and is rated at 5 *l*/s (4000 gph), but it is not known if this was the artesian or pumped supply. Owing to the high density of bores in the Katherine/Manbulloo area, not all are shown on the geological map, and their described locations and known hydrological data are listed in Appendix 1.

A bore at the King River Crossing on the Katherine/Willeroo Road began in soil probably derived from Lower Cretaceous rocks which there overlie the Ordovician *Ooloo Limestone,* and is presumably obtaining groundwater from aquifers within the older unit between 90 and 133 ft (28 and 41 m). The rocks have been described as porous calcarenite, sometimes argillaceous, and with rare seams of clay and calcareous sandstone.

Nothing is known about the groundwater regime of the undifferentiated Palaeozoic rocks in the southwestern part of the region, but the rock types are similar to the Merrina Beds, and groundwater would occur in modes similar to those in the latter unit. Nor is anything known about groundwater conditions in the Devonian *Dulcie Sandstone* in the region of this study, but to the southeast, in the central eastern part of the Northern Territory, there are springs at the unconformity between it and the underlying rocks (Smith, 1963).

Lower Cretaceous aquifers

Aquifers are known to be in the Lower Cretaceous Mullaman Beds in only a few bores in the region, but their presence in these beds can be inferred for several others by comparing the total depths of bores with the probable thickness of the Lower Cretaceous sediments. Also, some of the drillers' logs are specific enough to permit some stratigraphic interpretation of the producing sequences. Over much of the region the Lower Cretaceous rocks are absent or are too thin to be important as aquifers. Elsewhere the sequence contains a far greater amount of impermeable claystone and mudstone than sandstone. This last factor is very important in the area about the Murranji Track and the Cape Crawford Road. Here the sequence attains its greatest thickness but is virtually without aquifers, so that holes sufficiently deep to intersect the more favourable Cambrian aquifers had to be drilled.

The *Mullaman Beds* consist of non-marine sandstone of (?)Neocomian/Aptian age, overlain by interbedded marine siltstone, claystone, and sandstone of Aptian age, which in turn are overlain by Albian marine claystone and siltstone. The sandstone parts of the sequence have good aquifer characteristics, but their continuity has not been established, and many are at high elevations and hence above the watertable. The basal non-marine sandstone, which often contains chert pebbles derived from the Cambrian sequences, is definitely known to be the producing aquifer in bores drilled on Beetaloo station in 1965, in a bore (RN 5148) drilled on Mataranka station, and in Bore CCD on the Cape Crawford Road. Bore CCA on the same road obtains water at the unconformity between the basal Cretaceous sandstone and the Cambrian rocks (see Fig. 14). Two bores on Eva Downs station, O Bore and the Government Stock Route Bore near the homestead, intersected proven Cretaceous rocks which do not contain aquifers. Geologists familiar with the subdivisions of the Mullaman Beds have examined cuttings from all these bores except the Stock Route Bore, from which Crespin (1949) records a Cretaceous microfauna. The verbal description of rocks by the owners of Ucharonidge station, who also drilled the bores on the station, strongly suggests that several successful bores did not reach the Cambrian limestones and hence are obtaining water from the Mullaman Beds.

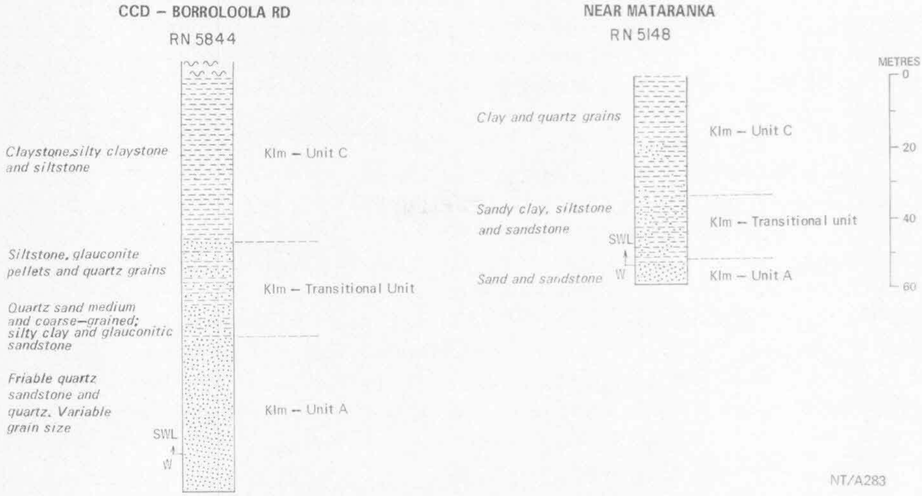

Fig. 14. Interpretation of logs of waterbores in the Mullaman Beds.

The drillers' logs for several bores on Newcastle Waters station are descriptive enough to suggest the position of the Cretaceous/Cambrian unconformity, and some record aquifers at depths commensurate with the younger sequence. The driller's log of No. 9 Murranji Stock Route records an aquifer in sand and gravel below white clay, yellow clay, and white sand and clay. This log strongly suggests that the aquifer is the basal sandstone of the Cretaceous sequence. A natural well occurs in a joint cleft 19 km south-southwest of Hidden Valley homestead. Although very narrow at the surface, the cleft widens downwards into a low chamber 5 m in diameter in which, on a sandy floor, water lies half a metre deep and about 6 m below the ground surface. The rock is a very fine-grained quartz sandstone, argillaceous in parts, and water moves partly along close joints and partly through the non-argillaceous components of the rock. This sandstone is either a bed in the upper marine unit of the sequence or, less likely, in the middle marine unit. In either case it would be underlain by relatively impermeable claystone and the groundwater is perched. It is the shallowest in the Cretaceous rocks of the region. The owner of Hidden Valley reports that at times several hundred head of stock have continuously watered from the well, which therefore can yield many cubic metres per day.

Although the Cretaceous beds yield water in parts of the region, they cannot be relied upon to do so at any given site. Successful bores begun in the Mullaman Beds have all been drilled well into the basal sandstone or, more often, in the Cambrian units below. Therefore any bore sited in the outcrop area of the Mullaman Beds must be programmed to drill below their base if necessary; the Cretaceous sequence is better regarded as non-productive overburden. This unreliability is the main reason for the failure of some deep bores, up to 147 m, to obtain water along the Cape Crawford Road, for the need for deep bores along the Murranji Stock Route, and for the generally greater depth of bores in the central part of the Main Plateau than on its flanks (Fig. 4). The contours shown in Figure 4 were drawn using as points thicknesses interpreted from bore hole data supplemented by thicknesses inferred by superimposing topographic contours and structure contours on the unconformity at the base of the unit.

Figure 3 shows structure contours on the unconformity at the base of the Mullaman Beds. The unconformity is important to the groundwater regime inasmuch as several bores obtain water in the unconformity zone, particularly in sink-hole fill in the Cambrian carbonate rocks.

Cainozoic aquifers

It is improbable that any bore is obtaining groundwater from either the *Birdum Creek Beds* or the *Camfield Beds* (both Tertiary). Only one, Larrimah Scouthole No. 3, is known to have begun in the Birdum Creek Beds, which it penetrated, and then passed into the underlying Tindall Limestone. Water was obtained in the limestone and the standing water level was about 16 m below the base of the younger unit. Bores on Wave Hill, Cattle Creek, and Camfield stations began in alluvium possibly overlying the Camfield Beds, but the recorded depth to the aquifers far exceeds the probable thickness of the Tertiary rocks. Some bores in the Helen Springs Sheet area may have begun in the *Brunette Limestone,* but there is no reason to suppose that groundwater is being obtained from that unit.

Massive Tertiary limestone crops out in the central part of the Wiso Basin, but its groundwater potential there is unknown, although it is a known producer to the south (Milligan et al., 1966). Chewings (1930) obtained shallow confined groundwater in wells which he sank through surface travertine and sandstone, but the relationship of these rocks to the massive limestone is not known. In some areas unconsolidated clay and sand overlie the Tertiary limestone; the sandstone, sand, and claystone section down to 135 ft (42 m) in GSW 4 contains several aquifer zones and may be part of the Tertiary sequence. They may, however, be younger compacted alluvial deposits in the old bed of the Lander River.

Groundwater discharges for varying periods as soakages in unconsolidated alluvium along the valleys of several watercourses. Water obtained from a shallow well in the bed of Coolibah Creek was used for road construction purposes. Copious quantities of water have been found in alluvium bordering the Katherine River in the vicinity of Katherine; as the river contains permanent water, these supplies also are probably permanent.

SUPPLY

Only a broad evaluation of aquifer characteristics in terms of supply can be made from the bore logs of this region. Very few bores have been adequately pump-tested. Some logs give no indication of the supply, and many merely state whether it is good, poor, or fair; many give an estimate only, and for some the supply recorded is the capacity of the pump used in the test or the equipment at present used on the bore. Very little has been recorded about the amount of drawdown under test and nothing about recovery.

Whereas about three-quarters of the bores in the central and eastern Barkly Tableland can produce more than 1.9 *l*/s (1500 gph), only 37 percent in this region are recorded as producing more than that amount; 13 percent are recorded as producing 1.9 *l*/s. This reflects the general pattern of low yields from bores in the Antrim Plateau Volcanics. Nearly 50 percent of the bores obtaining water from this unit yield less than 1.4 *l*/s (1100 gph), and only 37 percent yield more than 1.9 *l*/s. Similarly 50 percent of the bores in the Anthony Lagoon Beds yield less than 1.9 *l*/s. The best producers in the region appear to be the Tindall Limestone and the Montejinni Limestone; 75 percent and 60 percent of bores obtaining groundwater from the Tindall Limestone and the Montejinni Limestone respectively produce 1.9 *l*/s or more. There is insufficient data to gauge the supplies obtainable from the Merrina Beds and the Mullaman Beds. Most producing bores in these units yield 1.8 to 2.3 *l*/s (1400-1800 gph), but many bores fail to obtain water from these units.

Few drawdown figures have been recorded; however, for most bores a minimum value for the yield per metre of drawdown (specific capacity) can be obtained by assuming maximum drawdown, i.e. standing water level minus pump depth or aquifer depth. Table 7 illustrates the minimum specific capacity of selected bores in the Tindall Limestone, the Anthony Lagoon Beds, and the Antrim Plateau Volcanics.

TABLE 7. AVERAGE MINIMUM SPECIFIC CAPACITY OF SELECTED BORES

Rock unit	*Specific capacity* (*l*/s/m) *Average*	*Range*	*No. of bores*
Anthony Lagoon Beds	0.281	0.05-1.2	26
Tindall Limestone	0.426	0.03-1.5	35
Montejinni Limestone	0.360	0.04-1.0	9
Antrim Plateau Volcanics	0.149	0.006-1.2*	33

* For this unit only two results, 0.93 and 1.2, are greater than 0.4 *l*/s/m.

Despite the limitations of the data, Table 7 does reflect the relative ease of obtaining groundwater from the various units, easiest from the Tindall Limestone but rather difficult from the Antrim Plateau Volcanics. The drawdown during pumping tests of several hours duration was recorded for bores in several units (Table 8). Table 8 also shows that the availability of water is greater in the Tindall Limestone than in the Antrim Plateau Volcanics.

TABLE 8. PUMP TESTS ON SELECTED BORES

Bore (*Reg. No.*)	*Aquifer*	*Drawdown* (metres)	*Yield under test* (*l*/s)	*Duration of test* (hours)	*Specific capacity* (*l*/s/m)
150	Tindall Limestone	1.8	2.2	24	1.16
154	Tindall Limestone	5.8	2.3	48	0.41
557	Tindall Limestone	7.6	1.9	—	0.25
1443	Tindall Limestone	14.6	7.6	—	0.52
1827	Tindall Limestone	1.2	1.6	—	1.35
2522	Tindall Limestone	1.2	32	26	27.4
2946	Tindall Limestone	3.1	2.3	19	0.75
4709	Tindall Limestone	1.7	2.2	7	1.23
5329	Tindall Limestone	8.8	6.3	10	0.70
1533	Mullaman Beds	0.8	1.8	7	2.28
4882	Mullaman Beds	0.6	1.5	—	2.49
5423	Antrim Plateau Volcanics	19.5	1.0	—	0.05
5444	Antrim Plateau Volcanics	2.1	1.4	—	0.66
5012	Oolloo Limestone	0.4	0.8	2	2.24
4918	Alluvium	1.6	11	—	6.88

Caves in the limestone usually provide good supplies, but the relatively low value of 0.25 l/s/m for Bore No. 557 is anomalous. There is no lithological log for this bore, which is at the site of Birdum Stock Route No. 5, but the log of a bore, RN 53, at the same site states that water was obtained in a zone of 'broken limestone and caves' at about the same depth as that recorded for No. 557. Probably these bores intersected groundwater which is replenished by water movement along joints and fractures which have impressed their hydrodynamic characteristics on the aquifer system.

Certainly there is little likelihood of direct recharge to the cave system by interconnexion to open sinkholes as the log for RN 53 suggests an overburden of 230 ft (70 m) of impermeable mudstone and claystone of the Mullaman Beds. On the other hand the very large value of 27.4 l/c/m for Bore No. 2522, near Katherine township, strongly suggests that the bore is tapping a large flooded underground cave system which has a nearby direct connexion to a recharge zone. Cave systems connected directly to the surface by means of open sinkholes and very open vertical joints are known in the area. Probably saturated alluvium adjacent to the permanent Katherine River overlies the Tindall Limestone and transmits considerable quantities of water to the cave system penetrated by the bore. The high transmissivity of the alluvium is shown by the specific capacity of 6.88 l/s/m for the test bore RN 4918, which is near the river.

The differences in the specific capacity of the other bores in the Tindall Limestone presumably reflect the effects of the various hydrogeological characteristics of the aquifers—joints, fractures, presence of caves, and differences in grainsize and texture of various rock types. The big differences in specific capacity which can be expected in different hydrogeological circumstances are well shown by the two bores listed in Table 8 which are obtaining groundwater from the Antrim Plateau Volcanics. Bore RN 5423 (Stock Inspector's Residence, Top Springs) is drawing water presumably from joints in a rock described as very fine-grained hard basalt and has a specific capacity of 0.05 l/s/m. But Bore RN 5444 (New Town Bore, Top Springs), which is obtaining water from sedimentary beds within the Volcanics (see Fig. 12), has a specific capacity of 0.66 l/s/m. The specific capacities of the two bores obtaining water from the Mullaman Beds are similar, i.e. about 2.5 l/s/m. Both are obtaining water from the coarse beds of the freshwater Unit A at the base of the sequence, and the high values indicate the potential of the beds. Unfortunately, these rocks are generally above the watertable as shown in an earlier section, or, being discontinuous, are cut off from recharge by the overlap of the impermeable mudstones and claystones of the younger marine units.

I. R. Binch (NTA, pers. comm.) states that the aquifers tapped by bores on the Cape Crawford Road east of Daly Waters have a very high transmissivity. Because of equipment limitations they could not be pumped at rates greater than 15 l/s (12 000 gph), but at this yield there was little or no observable drawdown. Producing aquifers are the Tindall Limestone along the western part of the road, the Anthony Lagoon Beds along the eastern part, and, in Bore CCA, the unconformity between the Mullaman Beds and the Tindall Limestone.

In terms of geographic distribution, specific capacities greater than 0.4 l/s/m (based on the maximum possible drawdown) are most common on the eastern flanks of the Ashburton Range and about Brunchilly homestead, along the Stuart Highway from north of Newcastle Creek to the vicinity of Katherine, between Birrimba, Old Birrimba, and Killarney homesteads, and along parts of the Murranji Track and in the western environs of Lake Woods. Moderate values, greater than

0.2 l/s/m, occur north of the Barkly Stock Route and between Ucharonidge and Newcastle Waters. Low values occur between Toudinny Creek floodout and the Attack Creek floodout, along the Dry River Stock Route, and about Wave Hill and Cattle Creek homesteads.

HYDRODYNAMICS

The potentiometric surface

The recorded standing water levels for 300 bores have been converted to heights above sea level and the contours of the potentiometric surface drawn (Fig. 15). The contouring was done with no regard to the age and stratigraphic position of the producing aquifer.

Randal (1967) has shown that the Anthony Lagoon Beds and other carbonate units in the central and eastern part of the Barkly Tableland contain several aquifers which in most of the bores have a common potentiometric surface and are regionally interconnected. Data presented in Appendix 1 of this Bulletin show that in the northern Wiso Basin and environs also, many of the bores in the Anthony Lagoon Beds each intersected two or more aquifers whose standing water levels are at the same elevation, i.e. the hydrostatic heads in the aquifers have been equalized by interconnexion. Consequently on a regional scale the unit may be regarded as a single aquifer system. Similarly the data in Appendix 1 show that the Tindall Limestone also may be regarded as one regional aquifer system, particularly as there is strong geological as well as hydrological evidence for interconnexion between aquifers in this unit.

Several aquifers have been encountered in bores in the Merrina Beds and again each has a common potentiometric surface. Although a relatively impermeable mudstone unit separates two limestone units in the Montejinni Limestone, there is some evidence of interconnexion within the formation. The Anthony Lagoon Beds, the Tindall Limestone, and the Montejinni Limestone between them represent contemporaneous carbonate deposition in much of the Daly, Wiso, and Georgina Basins (p. 24). Because of the resulting regional continuity of carbonate rocks, the three units may be regarded hydrogeologically as one rock body. Furthermore there is some evidence of groundwater interconnexion between the Middle Cambrian rocks and both the overlying Cretaceous rocks and the underlying Lower Cambrian volcanics, and between the volcanics and the underlying Precambrian rocks. This aspect is discussed in the section on groundwater movement. Hence, despite evidence for local barriers between aquifers in the same rock unit and between aquifers in superimposed rock units, all units can be regarded as regionally interconnected and groundwater in the Wiso Basin and its environs has one potentiometric surface, shown in Figure 16.

The potentiometric surface broadly reflects the regional topography. The regional slope of the land surface on the Main Plateau is from south to north; the regional slope of the potentiometric surface is from about 250 m above sea level along the line of scoutholes in the Green Swamp Well Sheet area to less than 90 m above sea level in the Daly River Basin. Also, topographic features within the Main Plateau are reflected by the potentiometric surface. The surface attains an elevation of 280 m about the Ashburton Range between Tennant Creek and Helen Springs, and drops rapidly to the east and the west into the lower country bordering

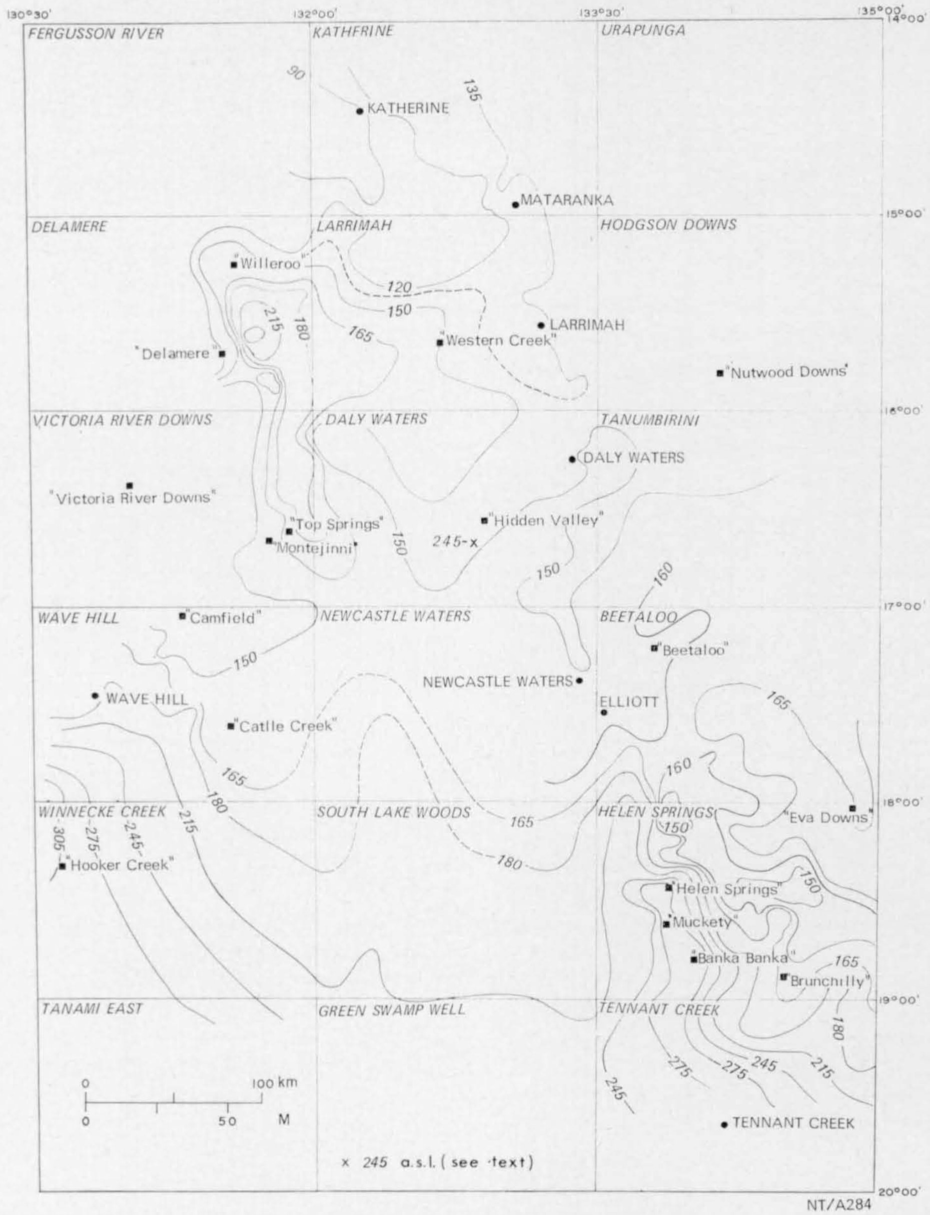

Fig. 15. Regional potentiometric surface.

the ranges. The northern extension of the Range is reflected by spurs in the 165, 180, and 210-m contours trending towards Elliott township.

In the western part of the region about Hooker Creek homestead the surface slopes eastward in the direction of the surface drainage of Hooker Creek. The slope gradually swings northeasterly in the drainage direction of Cattle Creek and thence northwesterly, following the Camfield River. The western part of the Main Plateau from north of Top Springs to south of Willeroo is elevated country, and a strong ridge in the potentiometric surface occurs about the Plateau in this vicinity. The

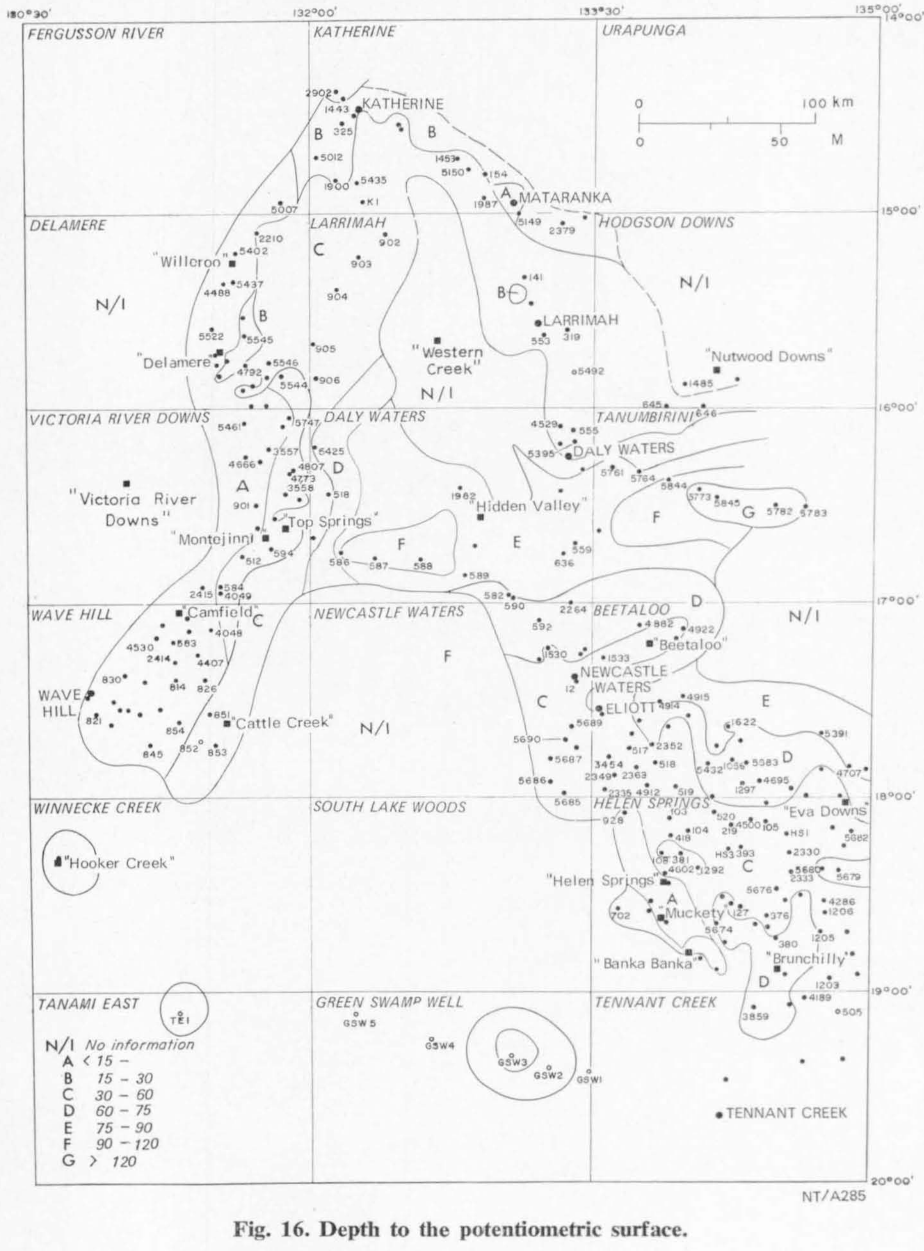

Fig. 16. Depth to the potentiometric surface.

150-m contour outlines a depression in the potentiometric surface in the central part of the Main Plateau; the depression is rather anomalous in shape and position, and may simply be the reflection of too few control points for realistic contouring. On the other hand other characteristics in the groundwater regime do at least justify the existence of such a depression even if not the shape of it as drawn. This is discussed in the section on groundwater chemistry.

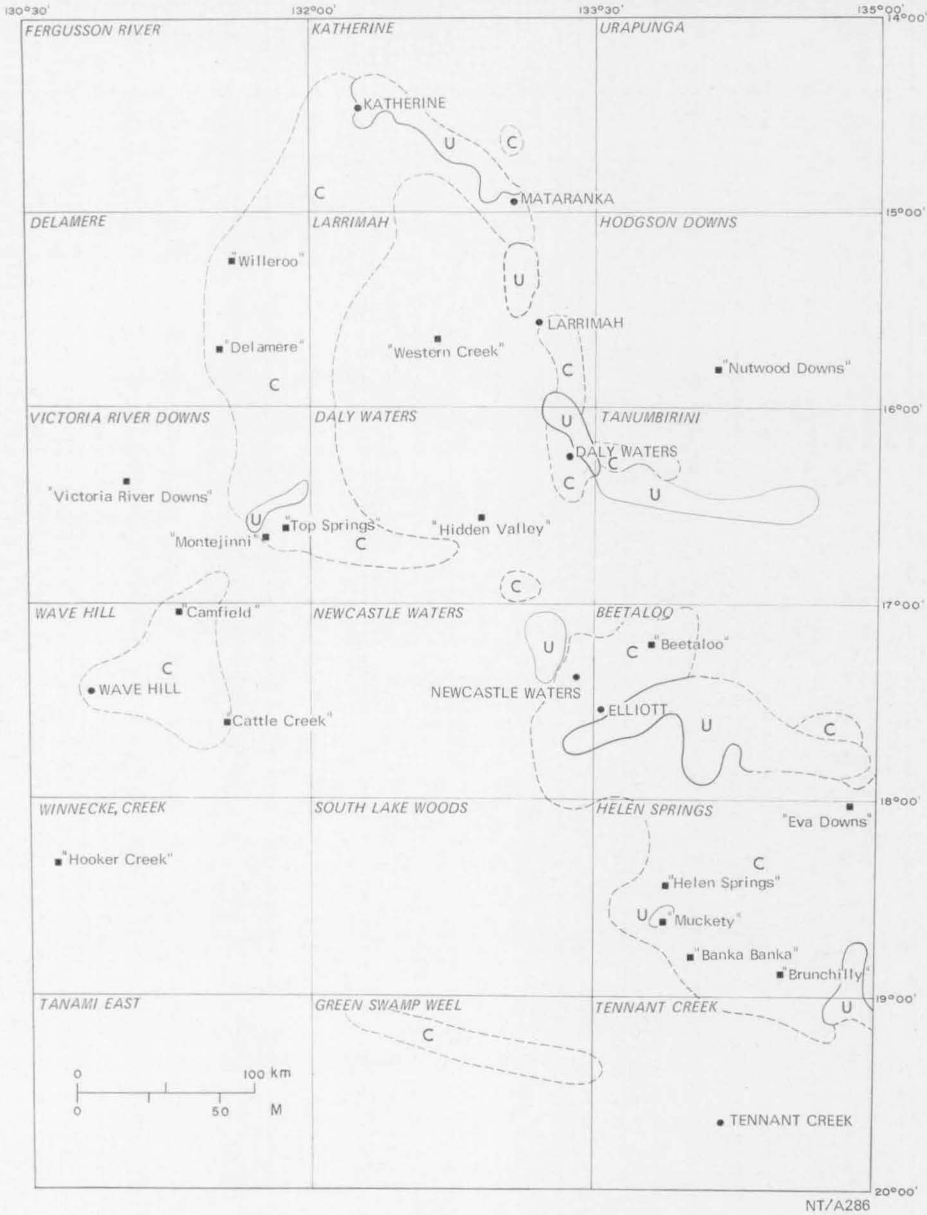

Fig. 17. Areas of confined and unconfined water.

The point marked 250 m on Figure 15 a few kilometres south-southwest of Hidden Valley homestead represents the standing water level in the natural well described on page 63. Although it indicates a potential recharge situation for the deeper aquifers, the standing water level here relates to a perched watertable and cannot be equated to the regional potentiometric surface, which records of the bores along the Murranji Track and bores to the northwest and northeast of Hidden Valley show to be about 150 m above sea level in this area.

About the basin of the Daly River and its southern environs, the potentiometric surface conforms to the shape of the Daly Basin. There is insufficient data in the eastern part of the Katherine Sheet area and in the western part of the Hodgson Downs Sheet area to define the surface in relation to the Roper River system. Data from bores north of Mataranka suggest it falls from about 140 m in the east to below 90 m about the King and Katherine Rivers to the west.

East of Lake Woods a saddle in the potentiometric surface in the southwest part of the Beetaloo Sheet area virtually separates the groundwater regime of the southeastern corner of the region from that in the central part of it. To the northwest of the saddle the potentiometric surface slopes generally northwards. To the southeast of the saddle a well defined depression in the potentiometric surface strikes southeastward and continues beyond the eastern margin of the study area into the central part of the Barkly Tableland, where it joins a depressed area in the potentiometric surface near Rockhampton Downs homestead (Randal, 1967, p. 29 and fig. 8). Hence in the Helen Springs and Tennant Creek Sheet areas the groundwater regime is continuous with that in the central part of the Barkly Tableland.

Figure 16 shows the depth to the potentiometric surface in the region.

The depth to the potentiometric surface over much of the Main Plateau is greater than the thickness of the Lower Cretaceous Mullaman Beds. Hence in much of the region these rocks are above the zone of saturation. However, as described on p. 62, the basal Lower Cretaceous sandstone, which has ideal physical characteristics as an aquifer, is well below the potentiometric surface in some areas and produces large quantities of water with little drawdown (see Table 8).

In several bores the potentiometric surface is at the same level as the first aquifer encountered, i.e. the groundwater is unconfined. In general, bores in this category occur in well defined areas which are shown in Figure 17. Several bores in a strip from the northwestern edge of Lake Woods eastward through Ucharonidge station to the vicinity of Shandon Downs homestead are presumed to be obtaining supplies from the basal Cretaceous sandstone. Unconfined groundwater occurs in the Anthony Lagoon Beds east of Brunchilly Creek in an area which adjoins one of similar groundwater regime to the east (Randal, 1967, fig. 9), and in the Tindall Limestone north and east of Daly Waters, and in an elongated strip between Katherine and Mataranka along the southeastern margin of the Daly Basin. Unconfined water is rare in the Antrim Plateau Volcanics. Unfortunately very few logs specifically state the standing water level of the first aquifer encountered if there are several, and the areas of unconfined groundwater may be larger than shown in Figure 17.

Groundwater Movement

Regional

It is apparent from Figure 15 that there are several directions of groundwater flow within the region. Many coincide with the direction of surface flow.

Although there is a regional slope in the potentiometric surface from south to north, it cannot be assumed that groundwater flow is uninterruptedly in that direction. Between the line of scoutholes in the Green Swamp Well Sheet area and the areas of high bore density in the northwest, north, and northeast of the Wiso Basin, no hydrological information is available, and undulations in the surface may not be revealed because of the absence of control points. There is some evidence from the salinity of the groundwater that the directions of flow in this area are more complex than indicated by the form lines on Figure 16, and this is discussed on page 81. Furthermore this northward slope is partly interrupted about Hidden Valley homestead and south of Western Creek homestead, where the disposition of ridges and valleys in the potentiometric surface suggests that groundwater flow is directed southwestwards, southwards, and southeastwards for some distances.

Changes in the direction of flow are also apparent on the western and eastern flanks of the Main Plateau. About Hooker Creek settlement the direction of flow is eastward but gradually swings northwards and thence northwestward, becoming coincident with the drainage system of the Camfield River and its main tributaries. Along the northern part of the western escarpment groundwater flow is westward to the drainage area of the Victoria River system and eastward to that of the Daly River and Roper River systems. Between Daly Waters and Hidden Valley groundwater movement is northwestward to the headwaters area of the Roper drainage system and southeastward to an area of black soil which trends towards Nutwood Downs. About Western Creek homestead groundwater movement is eastward towards the drainage area of the Roper River system.

Despite the tendency for the direction of groundwater flow about Western Creek homestead and Daly Waters to seek and then follow the direction of surface drainage of the southern tributaries of the Roper River, this parallelism does not continue north of Larrimah. Although the surface drainage swings northwards and thence eastwards towards the Gulf of Carpentaria, the general direction of groundwater flow maintains a steady northwest course to the area of the Daly River Basin where the 90 and 120-m contours on the potentiometric surface broadly outline the shape of the basin. Elongated areas of old alluvium in the Larrimah Sheet area connect the tributaries of the Roper River to the Dry River, a tributary of the Daly, and Randal & Brown (1967) suggest that the upper reaches of the southern part of the Roper system may have been part of the Dry River system before the region was warped during the Tertiary. Hence in this area the direction of groundwater flow may be controlled by elements of the earlier drainage systems; that is, the warping, although sufficient to change the direction of slope on the surface, has changed the amount but not the direction of slope on the potentiometric surface.

There is very little evidence in the northeastern part of the region on which to base concepts of groundwater movement in the central and lower reaches of the Roper River system. But on physiographic grounds it is probable that the potentiometric surface reaches a maximum height somewhat east of the 135 m contour drawn in the eastern Katherine and Hodgson Downs Sheet areas and thence slopes eastward. Groundwater movement towards the main Roper system is evidenced by the 160 and 150 m contours to the southeast and east of Daly Waters township.

Groundwater movement is westward and eastward away from the area of the Ashburton Range. To the west movement is towards the central part of the Wiso Basin, but west of the Tomkinson Creek floodout there is no information to define the trend. To the east of the Ashburton Range movement is east and northeast to the shallow depression of the northwestern extension of the grassy plains of the Barkly Tableland. This movement is complemented by a southwestward direction of flow from the area about Ucharonidge and Eva Downs homesteads. Both these directions are consistent with those described by Randal (1967) in the adjoining areas of the central Barkly Tableland. About Toudinny Creek groundwater flow is northwestward towards Newcastle Waters and southeastward towards the grassy plains of the tableland.

Interconnexion

From some of the bores in which the first aquifer was unconfined, insufficient supplies were obtained and the bores were drilled deeper. In several of these, aquifers tapped at a greater depth had a standing water level commensurate with the depth to the first aquifer. Also, in several bores where the groundwater in all aquifers was confined, the potentiometric surface was at the same position for all aquifers. Randal (1967) discusses these cases in respect to the carbonate sequences in the central Barkly Tableland and suggests interconnexion as an explanation for the phenomenon. In the first case hydrostatic heads, which tend to reach equilibrium by the upward movement of water through permeable and semipermeable zones, achieve complete equilibrium if a permeable rock lies at the level of the potentiometric surface, and hence the other aquifer is unconfined. In the second case the presence of confining beds above the first aquifer prevents further upward movement, complete equilibrium is not achieved, and all aquifers are confined.

The effects of interconnexion are apparent in bores in the Anthony Lagoon Beds in the Helen Springs and Tennant Creek Sheet areas, i.e. in the part of the region where the groundwater regime is continuous with that in the carbonate rocks of the central and eastern Barkly Tablelands. Randal (1967) fully discusses interconnexion in this unit and it will not be further treated here. There is evidence of interconnexion between aquifers in the Tomkinson Creek Beds, the Antrim Plateau Volcanics, the Tindall Limestone, the Montejinni Limestone, the Jinduckin Formation, and the Oolloo Limestone. Selected examples are discussed below.

A bore drilled in 1959 to provide water for Newcastle Waters township (RN 1899) encountered an aquifer at 176 ft (54 m), from which water rose 1 m in the bore. The supply was not recorded, but apparently was insufficient. The bore was deepened to 328 ft (100 m), obtaining 0.82 *l*/s (650 gph) at 326 ft (99 m), and the standing water level remained at 53 m. Unfortunately the driller's log is not detailed enough to permit interpretation of the geological conditions, but interconnexion is presumably due to jointing or other fracture systems in the rocks. Similarly Banka Banka homestead Bore (RN 5677) obtained increasing quantities of water from aquifers at depths of 14, 32, 58, 65, and 70 ft (4, 10, 18, 20, and 21 m), and the standing water level stood at 1½ m for all five aquifers. The driller's log records 'layers of quartzite and sandstone', but as the bore is near a major fault the aquifers are presumably interconnected through shattered rock in the fault zone.

Numerous bores in the northern and central parts of the basalt country west of the Main Plateau gave evidence of interconnexion in the Antrim Plateau Volcanics. The effect is most probably present in the southern part of the belt, but unfortunately the logs of bores in that part rarely record the depth of the main aquifer, let alone the depths and standing water levels for individual aquifers. A road construction bore on Humbles Creek (RN 5437) obtained a poor supply from an unconfined aquifer at 10 ft (3 m). Subsequent aquifers were encountered at 26 and 78 ft (8 and 24 m), and for both the standing water level was 3 m. Willeroo homestead Bore intersected aquifers at 64, 76, and 81 ft (19½, 23, and 25 m) and for all three the standing water level was 5 m.

This situation is not restricted to shallow aquifers in the Volcanics; deep aquifers also are in places interconnected with shallower ones. The road construction bore RN 5544 east-southeast of Delamere homestead obtained 1.15 *l*/s (900 gph) at a depth of 135 ft (41 m). The standing water level was 94 ft (29 m). The bore was deepened to 406 ft (124 m), where an additional 0.63 *l*/s (500 gph) was obtained, and further deepened to 422 ft (128 m), at which point the total supply from all three aquifers was 2.0 *l*/s (1600 gph). The bore was then drilled to a total depth of 585 ft (178 m) without improvement in the supply. The standing water level was measured after each period of shutdown and was constantly recorded as 29 m from when the drill penetrated the first aquifer until completion of the hole. Similarly Red Rock Bore on the Wave Hill Stock Route obtained water at 32, 232, 250, and 321 ft (10, 71, 77, and 98 m) with a standing water level of 9 m for all four aquifers. Interconnexion in the Antrim Plateau Volcanics is most probably effected by joints, but hydraulic equilibrium between inter-flow zones in the lavas may be attained in the vicinity of their junction (see Fig. 10).

Numerous bores in the vicinity of Katherine township and Tindall aerodrome each encountered several aquifers with a common standing water level. The conditions are apparently very similar to those existing in the Anthony Lagoon Beds—interconnected caves and large joints. Tindall Married Quarters Bore intersected aquifer zones between 60 and 80 ft (18 and 24 m) and between 97 and 112 ft (30 and 34 m), and the water from both zones stood at 18 m. The standing water level in a CSIRO farm bore 8 km southeast of Katherine is 19 m for aquifers at depths of 88, 104, and 127 ft (27, 32, and 39 m). Interconnexion exists in places between aquifers in the Tindall Limestone and the unconformity zone between it and the Mullaman Beds. Moorak Bore on Daly Waters obtained a small supply of unconfined water at 196 ft (60 m); this level is interpreted as the unconformity zone at the base of the Mullaman Beds (see Randal & Brown, 1967, p. 115). The bore was deepened to 220 ft (67 m) and encountered various aquifers below 206 ft (63 m) for which the standing water level was 60 m.

Interconnexion is known within the Montejinni Limestone from Dry River Stock Route No. 9 Bore (Charlies Hole). This bore began in the lower unit of the Montejinni Limestone and encountered two aquifers; the first, at 36 ft (11 m), contained unconfined groundwater, the second, which provided the main supply at 73 ft (22 m), had a standing water level of 11 m also. Although some other bores in the Montejinni Limestone indicate interconnexion within the formation there is no definite evidence of interconnexion between the three units of the formation. Some water has been obtained from limestone within the middle mudstone unit, but the unit is generally regarded as having a very low transmissivity.

This, together with its regional extent, would certainly tend to restrict the movement of water from aquifers beneath it to the overlying limestone unit. Monster Bore on Killarney station (RN 4807 in Fig. 13) began in the upper limestone unit but encountered no aquifers until the drill reached the unconformity at the base of the mudstone unit at about 102 ft (31 m). Although the supply was small the groundwater rose to 19 m, about 3 m, above the top of the mudstone unit. Similarly the road construction bore RN 5496 east of Delamere homestead obtained a mere 0.38 *l*/s (300 gph) at 2½ m above the base of the mudstone unit at 102 ft (31 m); the water rose to 22 m, 4 m below the top of the unit. Birrimba homestead Bore (RN 4518 in Fig. 13) also obtained groundwater about a metre above the base of the middle mudstone unit, but the rise was less than 3 m.

These examples suggest that the bottom part of the mudstone is an aquifer, but the middle part of it at least is an aquiclude and would probably prevent vertical interconnexion throughout the formation. On the other hand several bores that have penetrated the middle unit of the Montejinni Limestone have encountered confined groundwater well below its base, with standing water levels at or just below the base of the middle mudstone unit. Consequently even though the mudstone unit has the regional distribution and characteristics to be a confining bed of some importance, it appears to be above or only just at the watertable in parts of the region and in these parts has little influence on the hydrodynamics of the groundwater regime. But because few logs of bores which penetrate the Montejinni Limestone give detailed records, it is impossible to assess where the mudstone unit is hydrodynamically important and where it is not.

There are few bores in the Jinduckin Formation, but some logs indicate interconnexion in this unit also. A bore alongside Scotts Creek (RN 5007) intersected numerous aquifers between 50 and 126 ft (15 and 38 m) and all had a common standing water level of 4½ m. Interconnexion within the formation is evidenced by the data from BMR Scouthole Katherine No. 1 (Randal & Brown, 1967, appendix 1). This hole encountered several aquifers in the formation, and although the first contained perched unconfined groundwater, succeeding ones contained confined groundwater with a common standing water level of 55 m.

A bore near the King River (RN 5012) gave evidence of interconnexion in the Oolloo Limestone. It encountered aquifers at 90, 124, and 133 ft (27, 38, and 41 m), and the groundwater from all of them stood at 24 m.

An interesting feature of the groundwater regime of this region is the interconnexion not only within the various formations but also vertically between them, across the intervening unconformities. BMR Scouthole Katherine No. 1 obtained 1.25 *l*/s (1000 gph) from various aquifers within the Jinduckin Formation. At 355 ft (108 m) the drill passed into the Tindall Limestone and at 376 ft (100 m) the yield gradually increased until the bore could produce 6.3 *l*/s (5000 gph) at 413 ft (126 m). The standing water level was the same for the aquifers in both formations. Dry River Stock Route No. 5 Bore (RN 904 in Fig. 11) has a common standing water level of 48 m for aquifers at 183 ft (56 m) in the Montejinni Limestone and at 371 ft (113 m) in the Antrim Plateau Volcanics. Top Springs Police Bore and Killarney Monster Bore (RN 1913 and RN 4807 in Fig. 13) also have common standing water levels for aquifers in these same two formations. Horse Creek Spring Bore (RN 5522) on Delamere station obtained groundwater at 35 ft (11 m) in the Antrim Plateau Volcanics; standing water level was 7½ m. On deepening, the bore intersected aquifers in the underlying Victoria River Group at 90 and 110 ft (27 and 34 m), but the standing water level remained at 7½ m.

Recharge

Recharge is governed by the amount of rain-water percolating through overlying soil and rocks to the aquifers or by the amount of water brought into the region by subsurface flow. Nothing is known in detail about the latter factor, but indeed the slope of the potentiometric surface rather suggests that the subsurface movement of water in this region is away from it, except in the south. But even there the available data are insufficient to define the trend clearly. The first factor is controlled by the annual rainfall, by the characteristics of the sediments above the aquifer, and by the physiography.

Noakes (1954) and Randal (1967) consider that recharge areas in the Barkly Tableland are outcrops and lateritized outcrops on the margins of and within the basin, stream channels (mainly the upper parts) where sand occurs over sediments, and low rises once covered by lateritized material where light-textured soils now remain. All these kinds of recharge area occur extensively within the northern Wiso Basin and environs. In addition, Randal (1967) gave some evidence that recharge can occur in the areas of black pedocalcic soils. Certainly these soils are very impervious when wet, as is evidenced by the success of the raised earth tanks, or turkey nests, used for bore water storage. But during the dry season the clayey plains in some areas develop very wide and very deep cracks which could transmit large quantities of water to subcrops at considerable depth before closing up. The effects of wetting followed by desiccation on these soils is shown by the behaviour of some of the turkey nests: the walls are extremely retentive if kept moist and vegetated, but if bores are temporarily taken out of service and the tanks allowed to dry out the walls crack, and when the tanks are refilled they are often very leaky for some years after and are prone to complete failure. Admixed sand also increases the permeability of these soils.

Recharge to the Tomkinson Creek Beds and the Victoria River Group is probably by direct infiltration through fault zones and joints in the outcrop areas, by movement of water under gravity from overlying formations, and by percolation through overlying superficial sediments. Superficial deposits over the Tomkinson Creek Beds and the Victoria River Group are mainly sand, sandy soils, or gravels of varying texture which would permit rain-water easy access to groundwater storage. The stream beds mainly consist of similar material and a considerable amount of the original run-off may find its way to the groundwater body. Hays (*in* Barclay & Hays, 1965) made pertinent comments on the relationship between recharge, structure, and yield of bores in the Victoria River Group and these are discussed on page 50.

The physiography, particularly within the Ashburton Range, may be important to recharge conditions. Although the upper portions of the streams, which receive considerable run-off from adjacent steep-sided hills, traverse bare rock surfaces and open joint and fault zones, the gradients are steep and hence favour quick run-off. But in the valleys between the strike ridges the gradients are less and infiltration may be favoured. Farther downstream, decreasing slopes are accompanied by finer and tighter alluvial deposits. Many of the streams have floodouts on the flanks of the ranges, and although some are covered by fine silt, others have large areas of admixed sand over shallow subcrop. Unfortunately the valleys between strike ridges often coincide with siltstone beds, and infiltration into those may be minimal. Infiltration may be favoured where sandstone is interbedded with the siltstone or where valleys are underlain by sandstone softer than that forming the ridges. But because the rocks in the well defined strike ridges and valleys are generally steeply dipping, little of the potential aquifer is above maximum economic depth. Probably the most effective recharge areas occur where streams of moderate gradient in wide valleys are at right angles to the strike of jointed, gently dipping rocks. Extensive sand plains, which occur at various levels on truncated plateaux of the Ashburton Range, are potential recharge areas, particularly where they have a well defined but moderate slope towards watercourses. In these situations silt particles may be removed from the surface by run-off, thereby increasing the near-surface permeability of the plain.

Recharge in the Antrim Plateau Volcanics is effected by infiltration through joints and weathered rocks and by the movement of water through the inter-flow zones, as described earlier. It is not necessarily always a local phenomenon. As discussed in earlier sections there is some evidence that water movement may be affected by rock bodies or zones of large areal extent, and hence recharge at a given bore location may enter the groundwater regime many kilometres away. Nevertheless, until more definitive data are available some evidence of local potential recharge should be sought in selecting bore sites in this unit. The watercourses have sandy and gravelly beds and where their gradient is moderate should be influent streams. The rocks are well jointed and weathered, and well exposed in most of the streams. The soil cover on the Volcanics is thin and is thus absent from the bed of even the least incised streams.

Most of the soil over the Volcanics is very clayey—in places it is a slightly impure iron-stained kaolin and hence impervious. Consequently there is considerable run-off over some of the undulating hills and most recharge is probably by way of the stream channels. The clayey soils over the Volcanics do not exhibit the same degree of cracking as those over the carbonate rocks, and hence away from the streams recharge is effected only through outcrops containing open joint planes. Nevertheless raised earth tanks are unusual in the basalt country, as water under head can be transmitted through the very thin clayey soils to subcrops below, and the tanks thereby empty with no sign of leakage through the walls. Earth tanks have been successfully used only at sites where the drill has penetrated a considerable depth of clayey soil. The recharge conditions in the Helen Springs Volcanics are probably similar to those in the Antrim Plateau Volcanics.

Recharge situations for the Montejinni Limestone and the Tindall Limestone are probably alike. Direct infiltration through open joint and bedding planes in massive karst outcrops and through open sink-holes is probably very important. Streams passing through outcrops of weathered honeycombed limestone are probably influent. In addition, considerable quantities of water are received by percolation through overlying superficial deposits and through the overlying basal sandstone of the Lower Cretaceous Mullaman Beds, particularly in the northern part of the Main Plateau. In the Larrimah and the northern part of the Daly Waters Sheet areas numerous small depressions occur in the sandy soil overlying the basal Cretaceous sandstone, which is there very thin (see Fig. 3). These depressions are believed to be the surface reflections of collapse in the carbonate rocks or infilled sink holes. Although some contain silty matter, most contain and are surrounded by sandy or ashy-textured soil, and are the foci for nearby small runnels. Hence they probably receive surface run-off during heavy storms and may readily transmit water to the Cambrian aquifers. Although many of the stream beds contain silty and clayey material much of it develops large cracks and fissures. Early storms would probably produce some flow in these streams, but much of the water could be transmitted to shallow subcrop through these fissures. Brown (1895) commented on the lack of surface water in Birdum Creek in December 1894 despite heavy daily rainstorms and the fact that Lake Woods farther south was full. Recharge to cavernous limestone from the Katherine River has been discussed on page 66.

The mechanism of recharge to the Anthony Lagoon Beds in the central Barkly Tableland has been described by Randal (1967). Presumably similar conditions apply in the southeastern part of this region; recharge is through areas of outcrop and lateritized outcrop. Recharge may also be effected by groundwater movement along the eastward-sloping unconformity between the unit and the Tomkinson Creek Beds, and may possibly occur from the sandy parts of the floodout areas of the major watercourses. Recharge conditions for the Merrina Beds are probably similar; furthermore there is greater scope for recharge by percolation of rain-water, as the sandy soils in the south and southwest of the region are more permeable; the scarcity of streams there implies low run-off, but on the other hand the rainfall is low.

Recharge of the Mullaman Beds also is by way of lateritized and sand-covered areas. However, in the areas underlain by the younger claystone units of the Mullaman Beds, recharge can be hindered by the relative impermeability of the rocks. In the northern part of the region, where the permeable basal sandstone crops out or is close to the surface, recharge could be extremely rapid; but because of the cavernous nature and high storage capacity of the underlying carbonates and the permeability of the sandstone, water rapidly passes from it to the carbonates. Hence the regional potentiometric surface is relatively deep and the sandstone is generally a non-producer. Farther south, the periodic flooding of Newcastle Creek may make it an influent stream for the Cretaceous aquifers about Beetaloo and Ucharonidge stations.

Unlike the central Barkly Tableland, the northern Wiso and environs contain very few isolated prominences in the potentiometric surface which can be interpreted as recharge zones. There are, however, closed high-value contours along the northern part of the western escarpment to the Main Plateau. These suggest recharge to both the Antrim Plateau Volcanics and the Middle Cambrian carbonate rocks. In addition the linear ridge in the surface about the Ashburton Range suggests that it is a regional recharge zone. Although the groundwater regime in the Tomkinson Creek Beds within the central part of the range may be made up of several discrete systems, on the flanks of the range continuity between the groundwater regime of the younger rocks and that of the older ones can be reasonably postulated, and parts of the Range may be recharge zones for the younger ones. Probably recharge areas are where the streams have moderate gradients and cross the flanking sand plains which overlie Cambrian and Precambrian rocks. Recharge zones may also be reflected by large lobes in the contours such as occur in the 150 m contour south of Western Creek homestead and about Daly Waters, and in the 165 m contour about Eva Downs homestead and east of Banka Banka homestead. The groundwater in most of these areas has a relatively low salinity and is the bicarbonate type.

Probably, recharge takes place over most of the region as, except in the northwestern extension of the Barkly Tableland, there are no closed depressions in the potentiometric surface. Furthermore, unlike those of the Barkly Tableland, the superficial deposits in the region are mainly sand or light-textured sandy soils and rubble of lateritized rocks, all of which have a reasonably high permeability. The recharge paths are probably extremely complex and circuitous, with water moving in different directions at different levels but with an ultimate net transfer in the direction indicated by the regional potentiometric surface. This may explain some of the chemical anomalies discussed in the following sections. Groundwater movement could only be checked by the use of an extensive network of deep and shallow observation bores during the main recharge period, the wet season. The practical difficulties are enormous. But much information could be obtained if observation bores were constructed along the bitumen roads in the east and west of the region; and the bores already put down for road construction could well form a sound nucleus as they are well documented.

Randal (1967) suggested that far less than 0.35 percent of the precipitation falling over the Barkly Tableland need be taken into groundwater storage to balance accretion against withdrawal. There is no reason to suppose that a higher percentage would be required in the area of this study; on the contrary the available data suggest that it would be much lower. At present, the pastoral requirements in terms of withdrawal per bore and numbers of working bores are much lower than on the Tableland, and the rainfall in this region is greater than that in the Barkly Tableland. Over half the region receives more than 440 mm of rain per annum and more than three-quarters of it more than 320 mm. Only half of the central Barkly Tableland receives more than 320 mm per annum and less than a quarter of it receives more than 440 mm.

GROUNDWATER CHEMISTRY

QUALITY

Standards of quality

The determination of the total dissolved solids (TDS) by evaporation to dryness (at 180°C) provides a general indication of the salinity of a water sample and is used as a general indication of water quality, but the concentration of individual constituents must be taken into account in determining the suitability of water for specific purposes. Randal (1967) describes this aspect in some detail and discusses the recommendations of various authorities and workers in this field: the US Public Health Service as reported by Rainwater & Thatcher (1960), the Animal Industry Branch of the Northern Territory Administration as reported by Jephcott (1956), and recommendations based on the work of E. S. Simpson in Western Australia as reported by Ward (1951).

Table 9 summarizes the suggested limits for constituents in water to be used for domestic consumption.

TABLE 9. RECOMMENDED QUALITY OF DOMESTIC WATER

Constituent	*Maximum concentration in ppm*		
	Large town	*Small town*	*Station*
Total dissolved solids	1000	1500	3000
Hardness	200	300	
Magnesium	125	200	
Chloride	250	375	750
Sulphate	250	375	500
Nitrate	44-120		
Fluoride	0.8-2.0		
Lead	0.1		
Iron plus manganese	0.3		

The variations between the limits for towns and stations have no physiological basis; experience shows that people in isolated areas will accept, because of necessity, somewhat poorer quality water. There are, however, medical grounds for keeping the upper limits at the levels indicated and discussed in the references cited above. The table lists only normally encountered ions that have important physiological effects. Considerable quantities of sodium, potassium, calcium, and bicarbonate ions are present in most groundwater, but they are still harmless and tasteless at levels far higher than those found in most bore waters. Water would be condemned because of the concentration of some other harmful constituent or because of its high total salinity long before the concentration of these relatively harmless constituents became physiologically important. Other elements or ions are very important physiologically, but as Jephcott (1956) states '. . . their rarity is their safety factor'.

The determination of hardness is important in water intended for domestic or industrial use because of the undesirable reactions between soap and the constituents (mainly calcium and magnesium) which cause hardness; hard water requires extra soap to neutralize the hardness, the water and soap are difficult to lather, and unpleasant scums are formed during the reactions. The values of hardness have not been listed with the chemical analyses in Appendices 2 and 5, but the total hardness expressed as parts per million $CaCO_3$ may be obtained by multiplying the combined equivalents per million of calcium and magnesium from Appendices 3 and 6 by 50.05. The permanent hardness (non-carbonate hardness) may be obtained by multiplying by 50.05 any excess of calcium and magnesium over the sum of bicarbonate and carbonate expressed as equivalents per million. The temporary hardness is the difference between total and permanent hardness.

Although the quality of water for stock does not have to meet the same standards as water for domestic use, limits are set for various constituents and the total salinity. These also are discussed by the authors cited above and are summarized in Table 10.

TABLE 10. QUALITY REQUIREMENTS FOR STOCK

Constituent	*Maximum concentration in ppm*		
	Horses	*Cattle*	*Sheep*
Total dissolved solids	6250 (in work)	9400	12 400 (on satlbush feed)
	7800 (at grass)		15 650 (on grass feed)
Magnesium	300	400	500
Lead		0.5	
Chlorite	as sodium chloride, less than 75 percent of total maximum tolerance of dissolved salts		
Fluoride		6	
Nitrate		30-120	

There are many pertinent factors in assessing water quality for stock, i.e. climate, type of feed, season, and the salinity to which stock have become accustomed, and a great deal of variation can be expected in the reaction of stock to different waters.

Water quality and the rock units

The quality of groundwater as controlled by the chemical constituents and their concentration is dependent on two broad factors: the nature of the rocks which contain the water, and the hydraulic environment of rocks. The first factor is self-explanatory: water moving in rocks which contain readily soluble matter is more saline than water in rocks that do not. The second factor deals with the position of the groundwater in relation to the areas of recharge, areas of stagnation, and the hydraulic gradients. Within the same aquifer, water near the recharge zone is usually less saline than water which has travelled farther into the aquifer system. Consequently conclusions about the relative quality of groundwater from various formations must be modified by consideration of the hydrological environment of the formation. Table 11 lists the average salinity of groundwater from the various geological units in the region. The results from all bores which have been sampled are included in the figures, whether these are now operating or not, with the exception of two anomalously high values from the Antrim Plateau Volcanics near Camfield.

TABLE 11. AVERAGE SALINITY OF GROUNDWATER FROM ROCK UNITS

Formation of unit	*Salinity*	*Range*		*Sample No.*
Mullaman Beds	1063	330	2033	17
Merrina Beds	1207	303	3203	11
Montejinni Limestone	499	392	811	9
Tindall Limestone	782	242	2404	22
Anthony Lagoon Beds	1306	218	4583	65
Antrim Plateau Volcanics	530	217	1654	42
Helen Springs Volcanics	607	294	929	8
Victoria River Group	582	399	750	4
Tomkinson Creek Beds	1096	288	2520	4

The table shows that most of the groundwater in the region is fit for domestic use. The water from the Anthony Lagoon Beds and the Merrina Beds has the highest average salinity, but in fact some of the water from these units is less saline than that from the others. The average salinity for these units is heavily weighted by samples taken from bores obtaining water at points far from recharge zones. This aspect is discussed on page 98.

The low average groundwater salinity for the Antrim Plateau Volcanics, the Helen Springs Volcanics, and the Montejinni Limestone is attributable to the location of sampled bores mainly near recharge zones. The low average salinity presented for the Victoria River Group is extremely misleading; only a few samples of water from this unit have been considered in this report and they too may be from bores close to recharge zones. Very saline water has been reported from some deep bores in the unit. Very saline water occurs in the Antrim Plateau Volcanics in a small area near Camfield homestead.

Except for some saline areas in the Beetaloo and Helen Springs Sheet areas and near Camfield homestead (Fig. 18), the magnesium, chloride, and sulphate contents of the groundwater are low enough for the waters to be used for domestic consumption.

The fluoride content of groundwater in all formations is, with a few exceptions, well below the recommended limit. These exceptions are the more saline waters in the eastern outcrop areas of the Anthony Lagoon Beds and adjoining areas to the north, and groundwater from some of the bores about Lake Woods and in the Green Swamp Well Sheet area, and from some of the bores near Cattle Creek homestead. High fluoride values, up to 2.5 ppm, were found in single samples elsewhere.

Pollution. Although the nitrate ion may be derived directly from aquifer rocks and is important physiologically, its main importance in chemical analyses of groundwater is as an indication of possible organic pollution. Nitrate ion is one of the constituents of animal wastes, sewage effluent, and the degradation products of dead animal and vegetable tissues; these are all associated with bacterial activity. Pollution of a groundwater supply by man generally occurs in situations of local recharge where percolating rainwaters pass over or through contaminated soil and rapidly move into the aquifer. It may also occur if faulty bore construction permits contaminated water to pass downwards through the annulus between the casing and the walls of the bore. Polluted water may be carried considerable distances in limestone terrains because of the high effective permeability of the rocks and the consequent lower chances of mechanical filtration.

Laws (NTA and BMR file notes) describes pollution of a bore at Hooker Creek Welfare Settlement, and points out the pollution risk in two others. Large quantities of bacteria were found in No. 5 Bore, which apparently is polluted by piggeries and waste disposal areas. The nitrate content reported by Laws ranged up to 31 ppm, reported as ppm NO_3^-; it is not clear if this is actual nitrate content or nitrogen content attributable to nitrate ion.

Bores in the outcrop areas of the Tindall Limestone are prone to pollution unless adequate precautions are taken. This formation is extremely cavernous and probably receives considerable direct recharge through open sinkholes. Disposal of waste material and dumping of garbage into sinkholes in areas of high population and bore density is extremely hazardous and if unavoidable should be carefully planned.

High nitrate values have been reported in samples of groundwater from aquifers in the Anthony Lagoon Beds in the eastern part of the Helen Springs Sheet area.

GEOCHEMISTRY

Chemical Determinations

Total Dissolved Solids. The total dissolved solids listed in Appendices 2 and 5 have been determined by evaporation to dryness of the sample at 180°C. Isosalinity contours for the groundwater are presented in Figure 18. The range of groundwater salinity for the various rock units is given in Table 11.

Over most of the region the salinity is less than 2000 ppm; higher salinities occur in large areas in the Green Swamp Well Sheet area and in the eastern part of the Helen Springs Sheet area. In the former case the contours are based on the few data available from the line of BMR scoutholes between Tennant Creek and Hooker Creek. The position of the 2000-ppm contour is speculative, although some high values are known along the Murranji Track to the north, and on the western flanks of the Ashburton Range to the east. The contours are most accurate in the Helen Springs Sheet area, where the sample density is very high, and their positions are validated by the conformity of the values with those in adjoining

Fig. 18. Isosalinity contours.

areas of high salinity in the central Barkly Tableland (Randal, 1967). The salinity here appears to be controlled partly by hydraulic environment and partly by aquifer composition, and this is discussed on page 97 to 99.

Two bores near Camfield homestead obtain saline water from aquifers in the Lower Cambrian Antrim Plateau Volcanics. One bore, RN 4767 near the Camfield River, obtains water at a depth of 40 ft (12 m) having a salinity of 2400 ppm. The other, RN 4707 6 km away, obtains water containing 4,600 ppm total dissolved solids from 210 ft (64 m). The high salinity is anomalous as surrounding bores have a salinity of less than 750 ppm. The waters from these bores have an exceptionally high sodium and chloride content and have a very similar composition to bore waters in the Barkly Tableland which owe their high salinity to hydraulic environment.

The low salinity of groundwater elsewhere in the study area is attributed to local recharge conditions, shallow groundwater environment, and the low solubility of material forming the aquifers. The salinity increases as bores become more distant from the recharge areas but the increase with distance is nowhere as rapid as in the Barkly Tableland.

Specific Conductivity. The specific conductivity of the samples determined at 25°C is listed in Appendices 2 and 5; Randal (1967) discusses the relationship between this parameter and the total dissolved solids for groundwater in the Barkly Tableland, and similar relationships have been found for groundwater in the Wiso Basin region. The ratio TDS/S.C. ranges from about 0.5 to about 0.75, although a few samples with a particularly high sulphate content have a ratio as much as 0.97. The average ratio for waters from the various rock units is presented in Table 12.

TABLE 12. AVERAGE SALINITY/CONDUCTIVITY RATIOS FOR GROUNDWATER FROM SELECTED ROCK UNITS

Formation	*TDS/S.C.*
Mullaman Beds	0.64
Montejinni Limestone	0.62
Anthony Lagoon Beds	0.66
Antrim Plateau Volcanics	0.64
Helen Springs Volcanics	0.58
Tomkinson Creek Beds	0.61

As discussed by Randal (op cit.) the ratio changes for high salinities and varies for differing chemical types of water. Figure 19 illustrates the essential linearity of the relationship for waters of low salinity from the Mullaman Beds, the Tomkinson Creek Beds, and the Anthony Lagoon Beds. Above 2000 ppm salinity there is considerable dispersion in the ratios for samples from the Anthony Lagoon Beds; not only do these waters have a relatively high salt content, but also chloride and/or sulphate ions tend to predominate over the bicarbonate ion.

Major cations. The sodium and potassium values listed in Appendices 2 and 5 have in the main been determined by flame photometry; they are not values computed by balancing the sums of anions and cations. The effect of these alkali metals in drinking water has been discussed in previously cited references; it is regarded as innocuous. But the sodium content is important in deciding the suitability of water for irrigation, because it affects the tilth and permeability of soils. An outline of the problem is given in Hem (1959), with references.

The *sodium* concentrations range from a few parts per million in recharge areas in the Tindall and Montejinni Limestones to nearly 1000 ppm in the saline waters from the Anthony Lagoon Beds. According to Hem (1959) waters in carbonate terrains usually have a low sodium content unless evaporites are present,

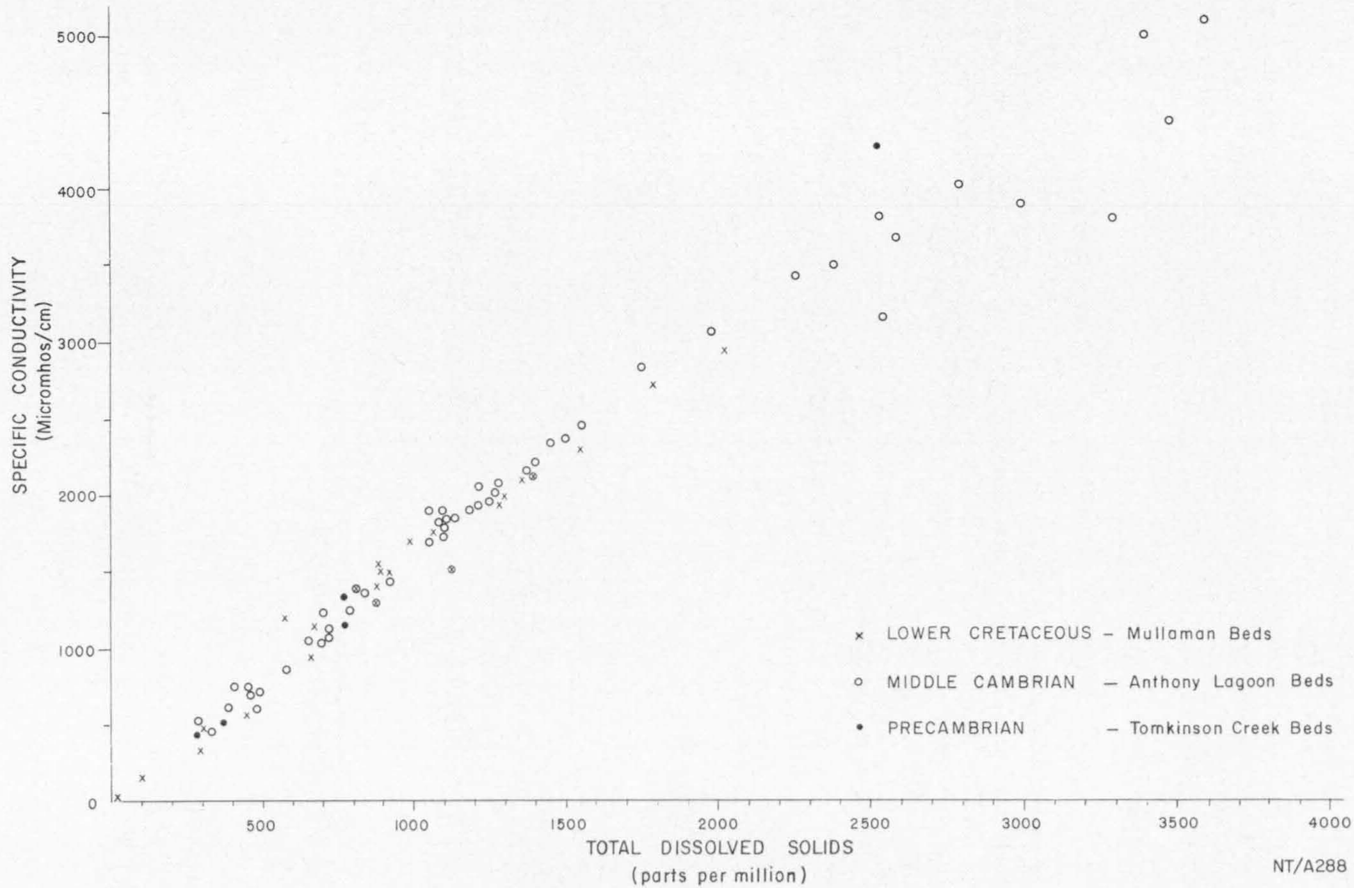

Fig. 19. Relationship between salinity and conductivity.

as both calcium and magnesium must first be dissolved to release the sodium. In addition the sodium content of carbonate aquifer rocks in this region (see Appendix 7) is very low: less than 500 ppm, in contrast to the range from 15 000 to 27 000 ppm for aquifer rocks from the Antrim Plateau Volcanics. Randal (1967) postulated that evaporitic interbeds provided high amounts of sodium to groundwater in the Anthony Lagoon Beds. The high values in the groundwater from the Anthony Lagoon Beds are highlighted by the generally low values in water from the Volcanics, despite the higher sodium concentration in the later rocks. The anomaly is partly because most bores in the volcanics are close to recharge areas whereas many in the carbonate unit are not. High sodium values occur in the saline bores southeast of Camfield homestead.

The *potassium* content of the water generally varies directly with the sodium content, but is usually much smaller. The ratio of potassium to sodium is generally higher in water from the volcanic rocks than in water from the carbonate rocks, although potassium is more abundant than sodium in the carbonate (see Appendix 7); the abundance of the two alkalis in the volcanic rocks is about the same. The different relative amounts in the two waters is probably due to availability. The potassium in the carbonate units probably occurs in detrital feldspar and mica and in illitic clays and shales, and hence is not as readily available as the sodium, which is probably present in more soluble form, the postulated evaporitic beds or adhering evaporitic particles. On the other hand, in the volcanics both the sodium and the potassium generally occur in the feldspars; hence as sodium becomes available by the breakdown of the minerals so too does the potassium. The ratio of sodium to potassium in the groundwater then becomes a function of the relative amounts and rates of dissolution of the sodic and potassic feldspars. Volcanic rocks with an unusually high alkali content are mentioned by Randal & Brown (1967), one sample being exceptionally high in potassium.

The *calcium* content of the groundwater in this region ranges from 20 to 30 ppm in the west and north to several hundred parts per million in the east; again the highest values occur in water from the Anthony Lagoon Beds. Water from Dry River Stock Route No. 1 Bore has the exceptionally high value of 600 ppm. This bore is obtaining water from the Tindall Limestone, groundwater from which usually has a calcium content less than 200 ppm. The sulphate content of the bore water also is extremely high (1538 ppm) and, despite the high total salinity, sodium and chloride are almost absent. The magnesium and bicarbonate contents, though rather low, are reasonable for water from carbonate rocks. The surplus calcium and high sulphate contents strongly suggest the groundwater at some stage is moving through a bed rich in gypsum.

The origin of the calcium content of water in the carbonate rocks is obvious. The source in the volcanic rocks is mainly feldspars and probably zeolites also. In two analyses (Appendix 7) of aquifer rocks from the volcanics the calcium content is higher than that of sodium; in another two it is less. Although sodium is somewhat more soluble than calcium the groundwater from the volcanics generally tends to contain more calcium than sodium. This is possibly because of calcium-rich zeolites in the amygdaloidal and vuggy inter-flow zones in which most of the groundwater movement occurs. Furthermore, calcite and prehnite are commonly associated with the zeolites in the Antrim Plateau Volcanics. In some areas, particularly the western watershed of the Camfield River, the waters from the volcanics are rich in sodium. This may be due to distance from recharge zones, particularly in the areas of high salinity; in other places it may be due to weathering of feldspars along joints. Generally, calcium is subordinate to sodium in the groundwater from the Helen Springs Volcanics; in these rocks albitization of the feldspars is common (Randal, Brown, & Doutch, 1966). Hence with further investigation and more data, it may be possible to assess the geological factors affecting groundwater occurrence by means of the relative amounts of calcium and sodium in the groundwater.

The importance of magnesium in drinking and stock waters has been previously discussed. It is beneficial in water used for agriculture as it flocculates the soil colloids and maintains soil permeability; it complements calcium in the reduction of sodium hazard in irrigation waters.

In this region the magnesium content of the groundwater is extremely variable: it is less than 40 ppm in many of the water samples from both the volcanic and carbonate formations, including the saline waters from the Anthony Lagoon Beds, but in some of the latter its concentration is slightly more than 200 ppm and some of the samples from the Antrim Plateau Volcanics have a concentration exceeding 150 ppm. Despite its generally low value magnesium predominates over calcium and sodium in several of the waters from the Antrim Plateau Volcanics between Killarney and Wave Hill, in two samples of water from the Helen Springs Volcanics near Banka Banka, in two samples from the Victoria River Group, and in water from bores believed to be in the Mullaman Beds near Ucharonidge homestead. It is the most common ion in two bores near Shandon Downs which may be drawing water from the Anthony Lagoon Beds. The source of magnesium in the carbonates is mainly dolomitic rocks and in the volcanics the ferromagnesian minerals.

The concentration of the major cations in the groundwater and their importance in classification of the water types is discussed further on page 93. The relative abundance of waters in which particular cations predominate is illustrated in Figure 20.

Major anions. The *chloride* ion content of the bore waters in this region is important only in waters that have a high salinity. As in the central Barkly Tableland, there is a marked relationship between chloride content and salinity; in this region it is most apparent in waters from the Anthony Lagoon Beds, i.e. in the western and northwestern extension of the Barkly Tableland.

The chloride content ranges from a few parts per million in the western part of the region to 1700 ppm (nearly 48 epm) in the eastern part of the Helen Springs Sheet area. High chloride values occur also in the Green Swamp Well Sheet area. Excluding two salty bores near Camfield homestead, the chloride content in the western part of the region is low except in the areas drained by the upper reaches of the Victoria River, the Camfield River, and Cattle Creek, where it is moderately high. It is generally low in waters from the Tindall and Montejinni Limestones, particularly in slightly saline waters near zones of recharge; these usually have the bicarbonate ion dominant.

The very high chloride content, 1800 ppm (52 epm), of water from RN 4407 is unusual for the groundwater from the Antrim Plateau Volcanics. Further, the higher chloride content is associated with a high alkali content, and other features which make the sample geochemically very similar to semi-stagnant groundwater. Farther south bores drilled through the volcanics have obtained salty water from the Victoria River Group, but according to the driller's log this bore encountered mainly basalt to the total depth of 236 ft (72 m) and obtained its main supply

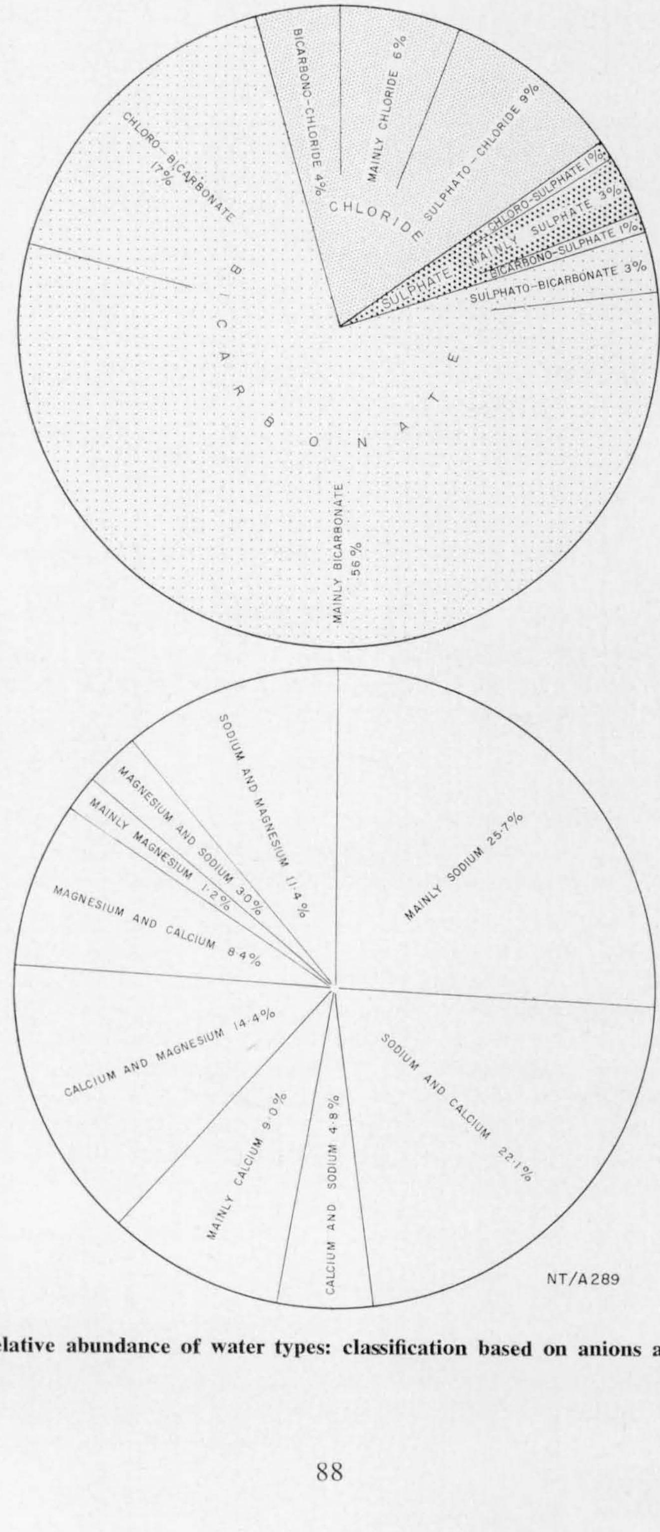

Fig. 20. Relative abundance of water types: classification based on anions and cations.

at 210 ft (64 m). This is deeper than most bores in the volcanics. Possibly the water originates in a saline groundwater body in the Victoria River Group and is entering the lower parts of the volcanic sequence because of interconnexion across the unconformity.

The absolute chloride concentration in the groundwater is not particularly high except in the areas discussed above, but the relative amounts are important in the geochemical classification of the groundwater discussed on page 93.

The possible sources of chloride ion in groundwater are extensively discussed in the literature and are summarized by Randal (1967). The difference in concentrations here cannot be readily explained unless a process of concentration by osmosis is envisaged. The gradual changes of salinity within aquifers and the evidence of interconnexion of aquifers tend to discount this possibility, at least on a regional scale. For anomalously high values in the central Barkly Tableland, Randal (op cit.) postulates possible interbeds of evaporitic sediments. This postulate could explain the high salinity of waters in the western and northwestern extension of the Barkly Tableland. It may also be pertinent for the highly chloride-charged waters in the Tindall and Montejinni Limestones and the Merrina Beds; furthermore these are marine sediments and chloride ion can have been trapped within the sediments during deposition.

The occurrence of chloride ion in other rock units such as the Victoria River Group, the various volcanic sequences, and the Tomkinson Creek Beds may simply be a function of the high solubility of chloride in relation to the other anions. However, intertidal conditions are postulated for formation of the limestone interbeds in the Antrim Plateau Volcanics, and minor accumulations of evaporitic sediments are possible. Halite pseudomorphs in the Tomkinson Creek Beds (Randal, Brown, & Doutch, 1966) indicate intertidal accumulation for that unit. Aquifer rocks in the region have chloride contents ranging up to 500 ppm. The highest values occur in samples from the Jinduckin Formation, in which halite pseudomorphs are extremely common.

A further possible source of chlorite is sea water which may have intruded the aquifers during the Cretaceous transgression, together with the leaching of salt areas after the seas had receded.

The *sulphate* ion content of the groundwater in this region ranges from a few parts per million in the western part to over 1500 ppm (32 epm) in the eastern part of the region. The highest amounts are in water from the Anthony Lagoon Beds. Values higher than 240 ppm (5 epm) occur in the saline area southeast of Camfield homestead and in a large belt trending southeastward from near Elliott to the Attack Creek floodout thence eastward to Rockhampton Downs in the central Barkly Tableland, where it joins high-sulphate areas previously investigated.

Abnormally high sulphate ion concentrations are not known in groundwater from the other Cambrian or Precambrian formations except in Ladabah Bore, which is in the Tomkinson Creek Beds west of the Ashburton Range, and in Dry River Stock Route No. 1 Bore, which apparently taps an aquifer in the Tindall Limestone southwest of Katherine. Some values higher than 240 ppm occur in bores which may be obtaining water from Cretaceous aquifers in the Beetaloo and Newcastle Waters Sheet areas.

A sulphate content of 2000 ppm has been recorded for the aquifer rocks of the Antrim Plateau Volcanics, but other parts of this formation contain 600 ppm or less (see Appendix 7). Values of 400 and 600 ppm are recorded for the Anthony Lagoon Beds and the Mullaman Beds, and the content of aquifer rocks of the Tindall and Montejinni Limestones is about 400 ppm.

The high sulphate content of groundwater from parts of the Anthony Lagoon Beds has been attributed to the probable presence of evaporitic beds; gypsum is known to occur in the soil derived from these rocks, and drillers have reported copi at depth. Sulphate may also be derived from pyrite, which occurs in the carbonate rocks in the north and in dark grey shales of other formations. Milligan et al. (1966) record gypsum in the Merrina Beds.

All the samples processed by AMDL were analysed for both *carbonate* and *bicarbonate;* carbonate was detected in only a few, which had abnormally high pH values. Some of the other analyses reported carbonate as present but as the pH in these samples is below 8.0 the analyses are suspect.

Although some abnormally high concentrations of bicarbonate ion, up to 750 ppm, occur in groundwater from the Anthony Lagoon Beds, there is no clear distinction between groundwaters from the various formations in terms of absolute concentration of bicarbonate expressed either in parts per million or equivalents per million. There is some distinction, however, when the content is expressed in terms of a percentage of the total anions; this is discussed in later sections. The mineral importance of bicarbonate ion is evident in Figure 20.

Fluoride. The effect of fluoride content on the potability of groundwater is discussed in an earlier section. Apart from the high values reported from the eastern part of the region there appears to be little geochemical significance in its distribution. The various fluoride contents merely seem to reflect the overall salinity increases in particular directions of groundwater flow. One aquifer rock of the Anthony Lagoon Beds contains 1500 ppm, but the one other sample contains 120 ppm; in the other formations the variation of fluoride content is not enough to permit significant correlation between fluoride concentration in the groundwater and that in the rock.

Silica. The silica in the groundwater is derived from the weathering of silicate minerals, notably feldspar, and by the solution of cryptocrystalline forms of silica such as chert and chalcedony. Chert is probably the main source of silica in waters from the carbonate rocks, and feldspars for those from the basalt. The mobility of silica in the region is evident in the development of silcrete and the silicification of rocks below or in the lower part of the laterite profile.

The concentration of silica in the groundwater ranges from less than 20 ppm in areas distant from recharge zones to nearly 70 ppm in areas which are considered to be either in or close to such zones. An apparent correlation between increasing salinity and decreasing silica content is probably false. Increase in salinity in this region is usually accompanied by an increase in sodium ion concentration, which in turn favours the dispersion of silica colloids. Thus the silica content of the water would tend to increase with increasing salinity. However, as the water moves farther from the recharge zones, silica is progressively absorbed onto the aquifer material, particularly in the calcium-rich rocks such as the carbonates, as calcium ion in solution tends to flocculate the colloidal silica and remove it from the water. The correlation therefore is between decreasing silica content and increasing distance from recharge zone; the pseudo-correlation between salinity and silica content arises because of the correlation between the latter factor and increasing salinity. Decrease of silica content with distance from recharge zones has also been noted in the central Barkly Tableland (Randal, 1967).

Boron. The importance of boron in water used for agriculture is discussed by Randal (1967); boron is not physiologically important in the concentrations normally encountered in natural waters.

The boron content of groundwater in this region ranges from less than 0.1 ppm in the western part to nearly 3 ppm in the saline areas in the east. There is some correlation between the boron content of the groundwater and the rocks of the formation. Values for the water from the Antrim Plateau Volcanics are generally very low—less than 0.5 ppm—although in RN 904 and 905 on the Dry River Stock Route the values are anomalously high—3.5 and 4.3 ppm respectively. The values for water from the carbonate rocks are low except for the Anthony Lagoon Beds. Groundwater from this unit in the eastern part of the region contains up to 2.8 ppm boron, and there is an apparent correlation between boron content and sodium content. The water from RN 6066 on the Cape Crawford Road contains 4.8 ppm; the water is believed to be from the Anthony Lagoon Beds. Groundwater from the other rock units generally contains less than 1 ppm boron. The amounts of boron in the aquifer rock analyses in Appendix 7 differ greatly. Up to 50 ppm is found for the Victoria River Group, the Anthony Lagoon Beds, and the Antrim Plateau Volcanics, and with one exception, 5 ppm or less for the other units. Presumably boron is not as readily available for solution in the Volcanics and the Victoria River Group as in the Anthony Lagoon Beds. Concentrations are much lower in groundwater from the Volcanics; the presence of evaporates in the Anthony Lagoon Beds is a possible explanation.

Lithium. The lithium content of the bore waters is very low, but again the highest concentrations occur in water from the Anthony Lagoon Beds. In the southeastern part of the region the concentrations range up to 0.5 ppm, but with few exceptions they are elsewhere far less than 0.1 ppm. Moderate amounts, 0.2 to 0.25 ppm, occur in water from presumed Cretaceous aquifers between Toudinny Creek and Ucharonidge homestead, and anomalous amounts of 0.14 and 0.11 ppm occur in RN 904 and 905 (Tindall Limestone) on the Dry River Stock Route.

Iron and Manganese. The manganese content is low—less than 0.04 ppm—and no geochemical trend can be detected from the available data. An anomalously high value of 0.38 ppm occurs in RN 906 on the Dry River Stock Route; it is not known which formation contains the producing aquifer.

The iron content also is normally very low—less than 0.05 ppm. Four abnormally high values—0.7 to 0.9 ppm—occur in the Helen Springs Sheet area, and although they are grouped in nearby pairs the probable reason for the abnormality is worn bore-head equipment.

Phosphate. The phosphate content is extremely low—usually less than 0.03 ppm. There is no definite geochemical correlation between phosphate content of the groundwater and the rock units, although there is a very slight tendency for the amount to be somewhat higher in water from the volcanics than in that from the carbonates.

Nitrate. The nitrate content ranges from less than 1 ppm along the Murranji Track and in the north of the region to almost 93 ppm in the southeastern part. High values were also found in the southern part of the Wave Hill Sheet area. The belt

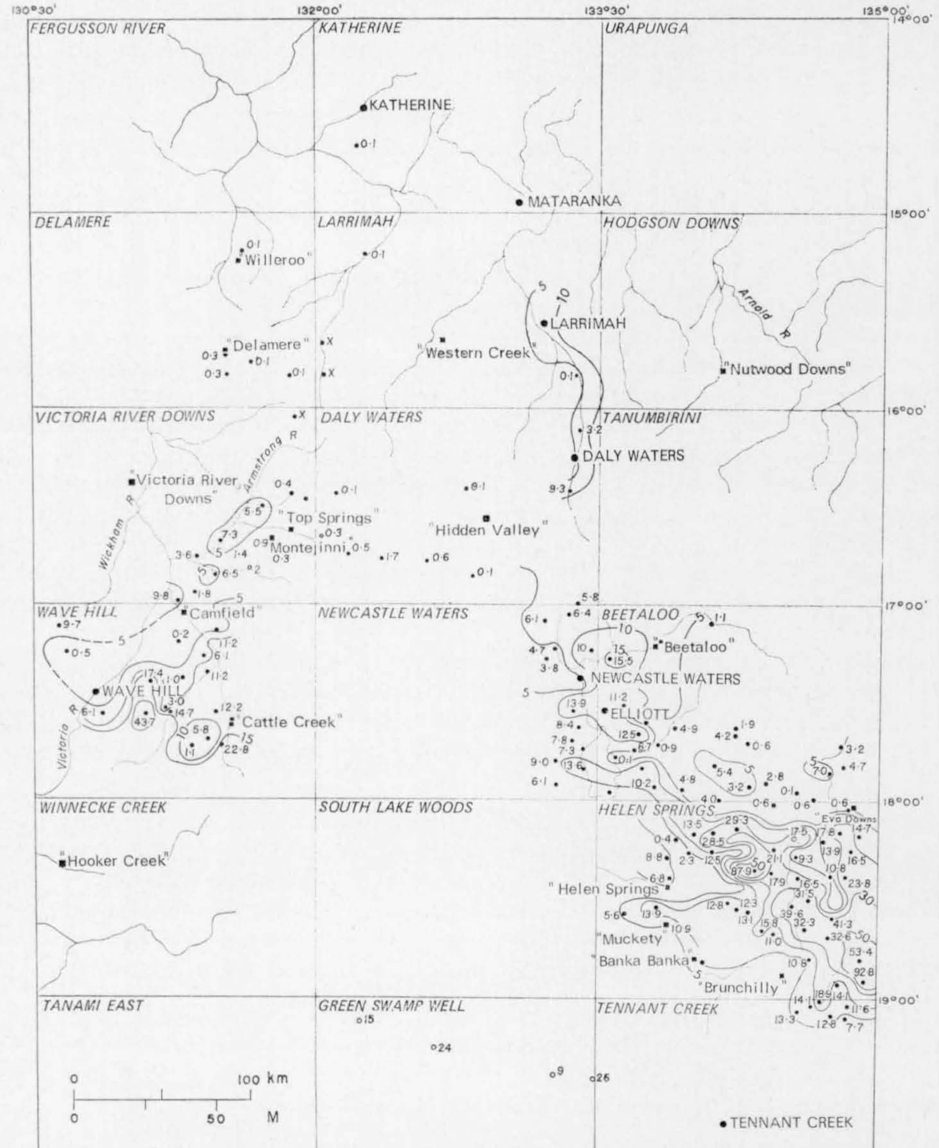

Fig. 21. Concentration of nitrate ion.

of very high values in the southeast (Fig. 21) generally coincides with the areas of high salinity, and the trends suggest that the content is controlled by aquifer composition rather than by bacteriological action. At present nothing is known about the nitrate content of rocks in the Anthony Lagoon Beds. Although pollution by stock is a possible source of nitrate in the shallow groundwater of the Antrim Plateau Volcanics, the high contents between Wave Hill and Cattle Creek homesteads rather suggest aquifer control. An interesting feature there is the decline in nitrate content in the regional direction of groundwater flow, possibly because of gradual dilution with increasing distance from the main source of the nitrate.

The ionic ratios. The ionic ratios $Cl^-/(Na^+ + K^+)$, Mg^{++}/Ca^{++}, $SO_4^{=}/Cl^-$, HCO_3^-/Cl^-, and $(Ca^{++} + Mg^{++})/(Na^+ + K^+)$ have been calculated and are presented in Appendices 3 and 6.

In the southeastern part of the region the trends of these ionic ratios are concordant with those established in the central part of the Barkly Tableland by Randal (1967), and support the general concepts of direction of groundwater flow and aquifer composition suggested for the Tableland. However, in the remainder of the Wiso Basin and its environs the paucity of the data at present precludes any useful geochemical interpretation of aquifer control on the ratios.

Chemical types of water

Two hundred and ten bore waters have been analysed, but of these 42 have not been analysed in sufficient detail to permit classification of the water in terms of dominant and minor anions. Analyses of groundwater from eight of the BMR scoutholes can be added to the remaining 168 analyses, giving 176 analyses which can be so classified.

The waters are divided into three main groups based on the predominance of chloride (Cl^-), sulphate ($SO_4^{=}$), or bicarbonate (HCO_3^-) ion*, and each group has been subdivided into three types according to the next most common ion. For example the chloride group has been subdivided as follows:

(*i*) mainly chloride type, in which $Cl^- >> HCO_3^-$ or $SO_4^{=}$.
(*ii*) sulphato-chloride type in which $Cl^- > SO_4^{=} > HCO^-_3$ but $Cl^- — SO_4^{=}$ is not > 20 percent of total anions.
(*iii*) bicarbono-chloride type, in which $Cl^- > HCO_3^- > SO_4^{=}$ but $Cl^- — HCO_3^-$ is not > 20 percent of the total anions.

The sulphate and bicarbonate groups are subdivided in an analogous way.

Figure 22 shows the spatial distribution of the various water types in the region; Table 13 shows the number of analysed samples in each category, and Figure 20 shows the proportion in each category.

TABLE 13. NUMERICAL DISTRIBUTION OF CHEMICAL TYPES OF GROUNDWATER

Dominant Anion / *Secondary Anion*	*Chloride*	*Sulphate*	*Bicarbonate*
Chloride	Mainly chloride (A) 12	Chloro-sulphate (BA) 3	Chloro-bicarbonate (CA) 30
Sulphate	Sulphato-chloride (AB) 17	Mainly sulphate (B) 6	Sulphato-bicarbonate (CB) 4
Bicarbonate	Bicarbono-chloride (AC) 8	Bicarbono-sulphate (BC) 1	Mainly bicarbonate (C) 95
Totals	37	10	129

(A, AB, AC, etc. refer to symbols in Appendices and Figures.)

Randal (1967) further divided the same anionic types of waters in the central Barkly Tableland into several classes based on the percentage which sodium, magnesium, and calcium formed of the total cations. This scheme was valid

* In terms of equivalents per million *not* parts per million.

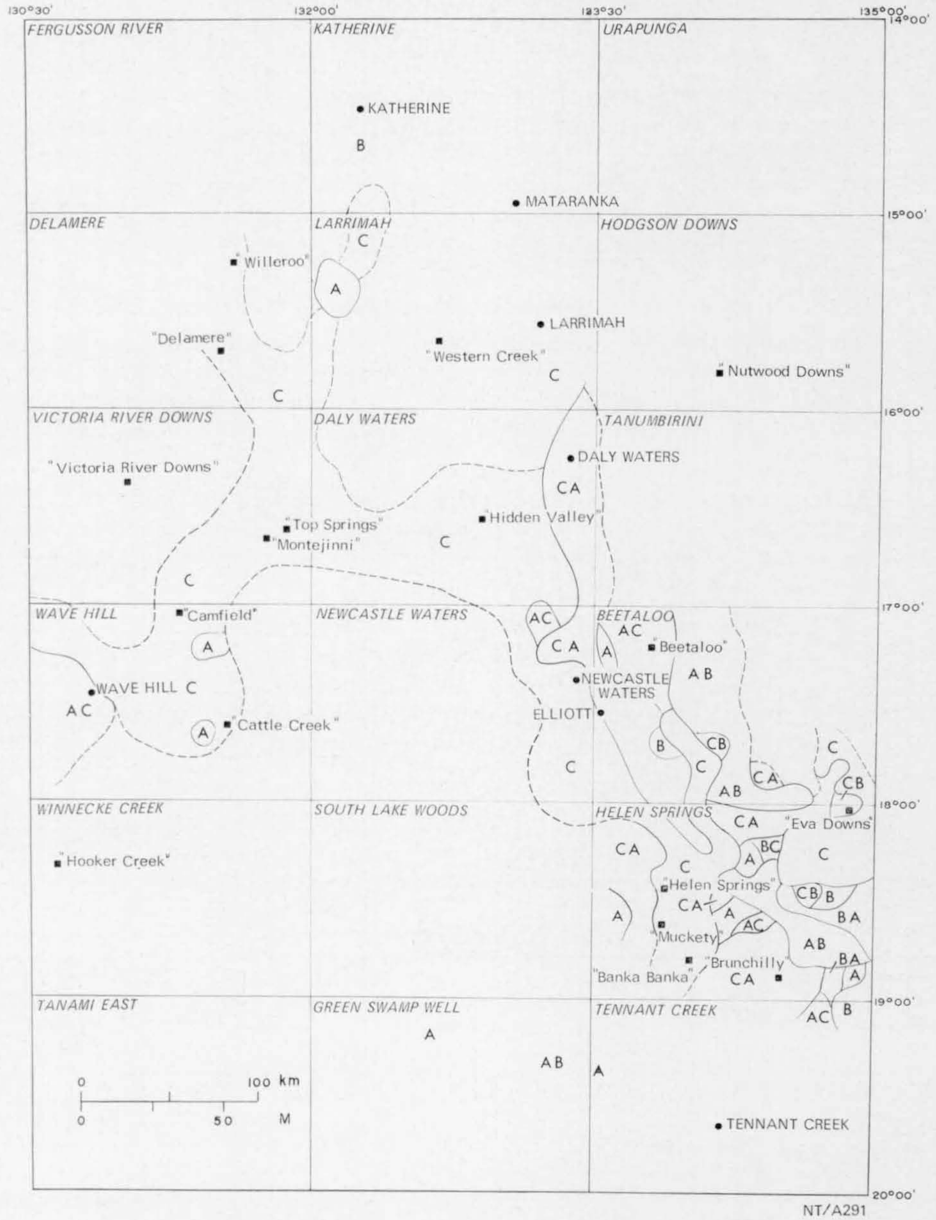

Fig. 22. Areal distribution of chemical types of groundwater.

inasmuch as the groundwater was essentially in the one rock body—similar carbonate formations—and there was a total of 265 analyses well distributed over cationic classes. However, in the northern Wiso Basin and environs several dissimilar formations are involved. Furthermore, the total number of samples and the number of samples within each class is low enough, except for the chloro-bicarbonate and mainly bicarbonate types, for the concept of an average composition to be misleading because of the potential wide variations from the mean. It has proved more useful to work from the idea of an average ionic composition for the water from each formation, and to examine the cationic contents from the viewpoint of spatial rather than numerical distribution.

The spatial (and numerical) distribution of the various anionic types is briefly discussed below, and comparisons made with waters of the central Barkly Tableland.

Chloride Group. Waters of the *mainly chloride type* are numerically few, in direct contrast to their dominance in the central Barkly Tableland. They occur in several isolated areas in the Beetaloo and Helen Springs Sheet areas in the east and in the Larrimah and Wave Hill Sheet areas in the west. Mainly chloride waters occur in three scoutholes in the Merrina Beds in the Green Swamp Well Sheet area in the south. They occur in the Anthony Lagoon Beds mainly, but also in isolated samples from the Antrim Plateau Volcanics, and in one from the Tomkinson Creek Beds. In all samples, as found in the previous study, sodium predominates over magnesium and calcium, and in half the samples from this region the sodium content was very much higher than that of the other cations. In most samples magnesium exceeded calcium.

The *sulphato-chloride type* waters slightly exceed the chloride type numerically. They come from two large discrete areas in the eastern part of the region and, like the mainly chloride type, are very saline. Their source is mainly the Anthony Lagoon Beds, but some in the Beetaloo Sheet area may be coming from Lower Cretaceous aquifers. As may be expected from a type in the chloride group, sodium is the most common cation; there are no samples in which either calcium or magnesium exceeds sodium. In a few calcium exceeds magnesium.

The *bicarbono-chloride* waters are few, but are widely scattered. They occur about Beetaloo homestead, in saline waters about the east part of the Murranji Track, in two small areas northwest and southeast of Brunchilly homestead, and about Wave Hill settlement and homestead. The main producing aquifers are the Anthony Lagoon Beds, but isolated samples have come from the Lower Cretaceous Mullaman Beds, the Lower Cambrian Helen Springs Volcanics, and the Precambrian Victoria River Group. Sodium is the most common cation in all the waters and in most calcium predominates over magnesium.

Sulphate Group. The sulphate group is both numerically and spatially the least important. However, the waters are extremely important from the utilization point of view, as sulphide is an extremely undesirable constituent and in this group its concentration is generally above the recommended limits. *Mainly sulphate type* waters are the most numerous in the group, followed in descending order by the *chloro-sulphate type* and the *bicarbono-sulphate type*. Calcium is the predominant cation in the mainly sulphate type, and rather suggests the presence of gypsum. An association of sodium with chloride occurs in the chloro-sulphate types, as in these sodium tends to be dominant, as it is also in the single bicarbono-sulphate sample.

The sulphate-group waters occur, with only one exception, in the western extension of the Barkly Tableland, and presumably originate in the Anthony Lagoon Beds. A single water sample of mainly sulphate type comes from the Tindall Limestone at No. 1 Bore on the Dry River Stock Route.

Bicarbonate Group. The bicarbonate group with 129 samples is numerically by far the most important of the groundwater groups in this region, in contrast to the central Barkly Tableland, where, although numerically greater than the sulphate group, it contains only about half as many samples as the chloride group. Figure 22 shows its spatial importance; it is extremely important from the point of view of groundwater use as it is the least saline water.

Within the group the *mainly bicarbonate type* is the most important; it contains almost 75 percent of the samples in the group and tends to contain the least saline water. It is extremely widespread. Except for a few pockets of chloride-group waters, it is universal on the western flanks of the Main Plateau and along the Murranji Track to near Newcastle Waters; from there the type occurs to the south about Lake Woods and on the western flanks of the Ashburton Range. Farther southward the area of this water type swings eastward to the central part of the range, leaving the western flanks to other water types. It then strikes southwards to Helen Springs homestead and thence to Banka Banka homestead. This area is joined northeast of Helen Springs homestead by another coming from the north about Ucharonidge homestead. A large area of mainly bicarbonate-type water occurs to the north, east, and south of Eva Downs homestead. It is contiguous with an area of bicarbonate-type water in the central Barkly Tableland (Randal, 1967). Mainly bicarbonate-type waters occur about Katherine and Larrimah and along the Cape Crawford Road, but there are insufficient control points to delineate separate areas on Figure 22.

Mainly bicarbonate waters occur in all the formations which contain producing aquifers.

The relative importance of the main cations in the mainly bicarbonate type is shown in Table 14.

TABLE 14. NUMERICAL DISTRIBUTION OF CATIONS IN MAINLY BICARBONATE WATERS

Dominant cation	*Next most common cation*	*No. of samples*	
Sodium		11	
Sodium	Magnesium	10	35
Sodium	Calcium	14	
Magnesium		2	
Magnesium	Sodium	4	19
Magnesium	Calcium	13	
Calcium		11	
Calcium	Sodium	7	41
Calcium	Magnesium	23	

As may be expected in bicarbonate-type waters, calcium and magnesium are abundant, but in a high proportion—nearly 37 percent—sodium is dominant or at least exceeds calcium or magnesium. Because of these sodium-rich bicarbonate waters, the relative abundance of sodium in waters is three-quarters of that of waters of the central Barkly Tableland, but the abundance of chloride-rich waters is only one third. This is because some groundwater in the Wiso Basin region is in volcanic rocks in which sodium can originate from feldspars without concomitant accumulation of chloride ion. As discussed in Randal (1967) and earlier in this Bulletin, there is a close association between chloride and sodium in the waters from the carbonate formations.

The sodium-rich bicarbonate waters come mainly from the Antrim Plateau Volcanics and the Helen Springs Volcanics. They occur about Willeroo and Delamere stations, about the Camfield River south of its confluence with Cattle Creek, and about Helen Springs and Muckety stations. An isolated occurrence is in Hidden Valley Bore in the centre of the Main Plateau; this bore penetrated the Cretaceous and Cambrian rocks to obtain water from the underlying volcanics. There are isolated occurrences in bores drawing water from carbonate rocks about Sturt Plain and from either Cretaceous rocks or Middle Cambrian rocks about Lake Woods. These recurrences may be due to base exchange reactions with sodium contained in interbedded siltstones and shales. The process of base exchange increases not the salinity of the water but merely the proportion of sodium in it; these waters are not unduly saline and are far less saline than those in the east in which sodium and chloride ion appear to be in association.

The *sulphato-bicarbonate type* waters are rare. They tend to occur near the boundaries between mainly bicarbonate waters and more saline sulphate or sulphato-chloride waters. Sodium is the dominant cation.

The *chloro-bicarbonate type* waters occur only in the eastern part of the region and are mainly produced from aquifers in the Anthony Lagoon Beds, although in the Beetaloo Sheet area some may be coming from the Lower Cretaceous Mullaman Beds. Wiggenty Well on Muckety Station produces this type of water from the Tomkinson Creek Beds, and Helen Springs No. 7 is also producing this type either from the Tomkinson Creek Beds or from the Helen Springs Volcanics. The type separates mainly bicarbonate-type waters from the saline chloride-type waters.

The quantitative importance of the chloride ion in this type is reflected by the dominance of the sodium cation. Calcium is dominant in only one of the samples, but although exceeded by sodium it is still significant in over half the samples of this type.

Geochemistry and Groundwater Environment

Concepts explaining the progressively changing composition of groundwater have been put forward by Schoeller (1959) and Chebotarev (1955) and have been summarized by Randal (1967, pp. 65-66). Under normal conditions groundwater enters the aquifer system as a bicarbonate-type water of low salinity and through the various physical and chemical reactions within the aquifer gradually changes to a chloride-type water of much higher salinity. Hence slightly saline bicarbonate waters are relatively closer to the zone of recharge than the saline chloride-type waters or the intermediate types such as the chloro-bicarbonates, bicarbono-chlorides, and those in which the sulphate ion is dominant or sub-dominant. Anomalies may occur because of concentrations of particular ions in various rock types in the aquifer system.

Although anomalies certainly are present there is a definite correlation between the geochemistry of the groundwater and its environment in this region. It is most pronounced in the northwestern extension of the Barkly Tableland, probably because there the greater density of bores provides control points for contouring the various parameters.

To the east of the Ashburton Range the slope of the potentiometric surface indicates that movement of the groundwater is eastward and northeastward towards the central depression of the Barkly Tableland. Figures 18 and 22 indicate a salinity rise and a progressive change from mainly bicarbonate-type waters to various types of the chloride group in the same direction. All three parameters imply a zone of recharge as indicated by the ridge delineated by the 165 m contour on the potentiometric surface above Eva Downs; the ridge is complemented by salinity increases in the direction of flow and is partly outlined by bicarbonate-group waters. Along the eastern boundary of the region these trends are in accordance with the trends in the central Barkly Tableland.

Elsewhere the lack of control points prevents the relationships from being accurately defined. The water of relatively low salinity at Hooker Creek settlement is a chloro-bicarbonate type. The potentiometric surface indicates that water movement is to the north and northeast, and there is an ill defined change to chloride-group waters in those directions; there is also a slight salinity increase towards the mainly chloride-type waters near Cattle Creek and Camfield homesteads. Despite these changes, the areas around Hooker Creek are producing mainly bicarbonate-type waters of relatively low salinity, even though the potentiometric levels are lower. A possible explanation for this phenomenon is that, although groundwater movement is northward and is accompanied by rising salinity, efficient local recharge to the aquifers in volcanic rocks is taking place throughout the western part of the region so that the upper levels of the aquifer system contain recharge water which has not travelled far. This implies that the saline water is moving through at depth. Certainly shallow bores are common in this area and although no analyses are available, several deep bores were abandoned because of saline water. Possibly the sodium-rich waters in this area (see p. 84) are those which have indeed travelled some distance from the recharge zones. However, with the present data it is virtually impossible to distinguish sodium enrichment because of greater distances travelled from that caused by the better availability in some areas of sodium from feldspars in the basalt.

Again, there is no marked increase in salinity or change in anionic composition westward from the ridge in the potentiometric surface from Top Springs settlement to Willeroo homestead. But the potentiometric gradients there are very steep and hence groundwater tends to move rapidly. Also there is ample opportunity for local recharge to shallow aquifers. Sodium-rich waters which occur there may be the result of base exchange as water moves away from the recharge zone; base exchange may raise the sodium content without any great increase in salinity.

The broad spur in the potentiometric surface west and south of Western Creek homestead and the complementary valley to its south are reflected by a re-entrant and spur in the 500-ppm salinity contour, together with a closed 1000-ppm contour. This salinity pattern confirms that there are reversals in the direction of groundwater movement despite the general northward slope of the potentiometric surface. Such reversals, as yet unidentified, may be responsible for the lack of accord between apparent direction of flow and the direction of increasing salinity.

The most striking discordance between the direction of slope of the potentiometric surface and the direction of increasing salinity is in the southern central part of the region. Immediately west of the Ashburton Range the potentiometric surface slopes westward towards the Wiso Basin; flow in this direction is further indicated by the increase of groundwater salinity and by the progression from bicarbonate to chloride-type waters. From the line of scoutholes in the Green Swamp Well Sheet area, three of which produced moderately saline waters of the chloride group, the regional slope of the potentiometric surface appears to be northward towards the central part of the Murranji Track, where, however, the waters are less saline and bicarbonate in type. This discordance may be explained by the lack of control points in the intervening large area; reversals of slope or salinity changes may be present but are not revealed by the available data. The explanation put forward for a similar discordance farther to the west may apply here; the saline water is in fact moving north but is masked by recharge water entering the aquifer system locally and diluting it. The intriguing point is that the direction of groundwater flow suggested by the salinity contours is also the general direction of dip and thickening of sediments in the Wiso Basin postulated by Milligan et al. (1966). The problem can only be solved by extensive drilling south and southeast from Hooker Creek and Cattle Creek to Tennant Creek and in the southern part of the Wiso Basin south of latitude 20°S.

Similar anomalies occur between Western Creek, Larrimah, and Katherine. Probably the key to the direction of water movement in these areas lies in the sparsely drilled Larrimah Sheet area, and also in the hydrogeologically unknown area of the Roper River watershed.

Geochemistry and the rock units

The chemical composition of the groundwater from some of the formations in terms of average percentage reacting values* is shown in Table 15. Triangular plots of actual analyses of groundwater from various formations are shown in Figure 23. Although formation geochemistry has some effect on the groundwater geochemistry, a great deal of the latter seems to result from the structural position of the units in the groundwater regime.

TABLE 15. AVERAGE COMPOSITION OF GROUNDWATER FROM SELECTED FORMATIONS

Formation	*Average percentage reacting values*						
	$Na^{+} + K^{+}$	Ca^{++}	Mg^{++}	Cl^{-}	$CO_4^{=}$	HCO_3^{-}	Type
Mullaman Beds (Klm)	47	28	25	32	19	49	CAnc
Montejinni Limestone (Cmm)	13	49	38	4	5	91	Ccm
Anthony Lagoon Beds (Cmy)	45	31	24	32	28	40	CAnc
Antrim Plateau Volcanics (Cla)	36	34	30	16	6	78	Cnc
Helen Springs Volcanics (Clh)	38	27	35	21	8	71	Cnm
Tindall Limestone (Cmt)	32	36	32	26	18	56	CAmn
Tomkinson Creek Beds (Plt)	32	32	36	36	13	51	CAmn

The average compositions of water from the Antrim Plateau Volcanics and the Helen Springs Volcanics are very similar although in the latter magnesium is significantly higher than calcium. Both formations tend to produce sodium-rich waters and both produce mainly bicarbonate waters. Figure 23 illustrates that

* In terms of 100 percent total anions and 100 percent total cations. The concept is the same as that shown in Appendix 3.

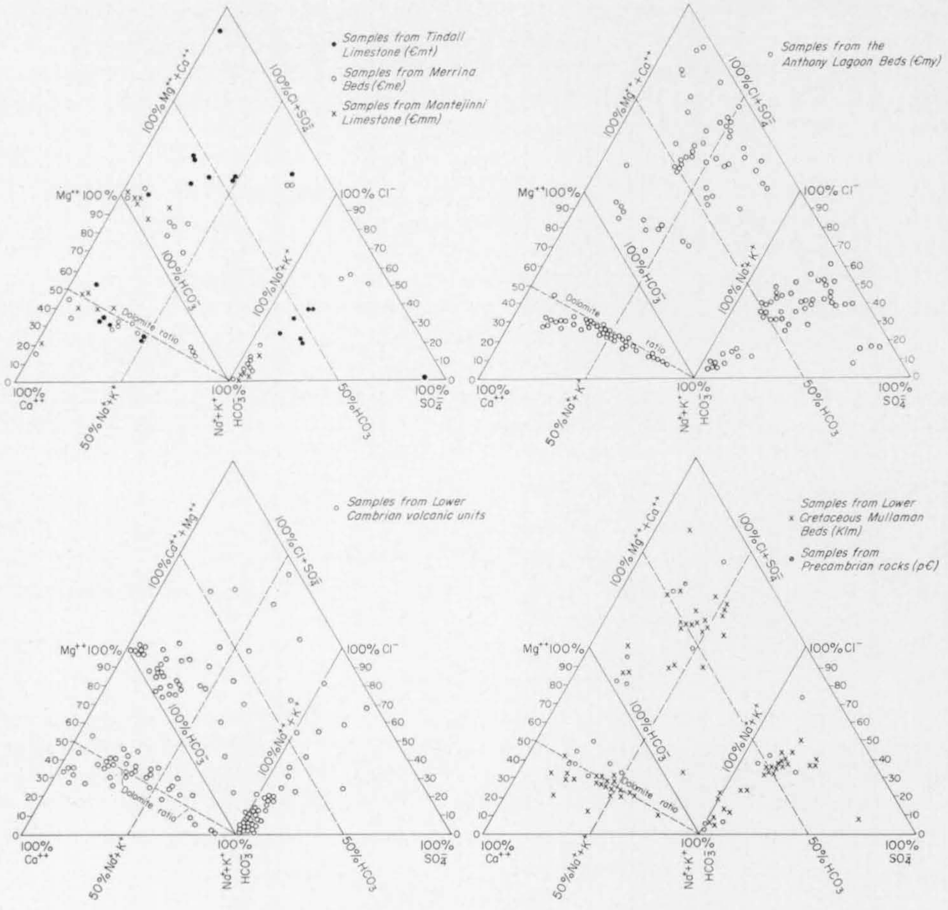

Fig. 23. Triangular plots of groundwater from selected formations.

increasing sodium content is accompanied by a rise in the Mg^{++}/Ca^{++} ratio (the dashed line represents a ratio of unity, and is called 'the dolomite ratio'), although for the very sodium-rich waters the trend is reversed because though the waters have very little calcium, they have even less magnesium. Possibly the reason is base exchange. The waters are particularly deficient in sulphate, although there is a tendency for it to rise with increasing chloride. The marked clustering near the bicarbonate apex clearly indicates the proximity of most of the sampling points to recharge zones.

The average anionic composition and the anionic trends for the Montejinni Limestone are similar to those for the two volcanic formations. There is a much stronger chloride influence in the waters from the Tindall Limestone and in part they are similar to those from the Mullaman Beds and the Tomkinson Creek Beds. The very high sulphate (and calcium) content of one of the samples from the Tindall Limestone is very much out of character. The sample was from the Dry River Stock Route No. 1 Bore and has been discussed previously; its composition strongly suggests the influence of gypsum and it has been ignored in the calculations for Table 15. The magnesium content tends to be well below the dolomite ratio line, although some samples are slightly above or below it. These samples are from the Montejinni Limestone, in which there appear to be more beds of dolomitic limestone than there are in the Tindall Limestone.

The groundwater samples from the Anthony Lagoon Beds provide a very interesting geochemical trend. As indicated in the table of average compositions they have a high chloride and sodium content; this is also immediately apparent from Figure 23, where, in the rhomboidal portion of the graph, the two are associated. This relationship suggests the presence of beds of evaporitic material within the carbonates of the unit. At the same time there is some evidence of base exchange; some of the relatively high sodium values fall low in the rhomboidal sector, towards the bicarbonate line. Base exchange could be effected by siltstone or shale beds which are known in the sequence, but this process cannot be invoked to explain fully the striking relationship noted between rising percentage of chloride, rising percentage of sodium, and rising salinity.

The dispersion in the anionic sector of the graph clearly reflects the passage from bicarbonate waters to chloride waters, i.e. recharge-zone waters to near-stagnant waters, although there are marked breaks in the point density. This progression is apparent also in figure 24 in Randal (1967), in which average values of sample from the carbonate aquifers of the adjoining region are plotted in the same way. The breaks are not as pronounced there as they are in Figure 23 in this Bulletin, probably because in this figure the plots are of actual sample values and not averages of values. The cation graph (left-hand triangle) for the Anthony Lagoon Beds shows a definite trend towards the dolomite ratio particularly as the sodium content rises. The interesting point is that the dolomite ratio ($Mg^{++}/Ca^{++} = 1$) is rarely exceeded. The cluster of the points immediately below the line is different from distributions for other formations, although some samples from the Mullaman Beds partly follow the same trend.

Dolomitic beds—both siltstone and carbonates—are well known in the Anthony Lagoon Beds, and it is reasonable to expect the Mg:Ca ratio in the water to approach that of the rock with increasing distance from the recharge zone, i.e. with increasing salinity, which in this area is concomitant with an increase in the sodium content. This affinity between the points and the dolomite ratio line also occurs in figure 24 in Randal (op. cit.) although there the dispersion is greater and indeed there are points well above the dolomite ratio line. The comparative dispersion for the samples in the earlier work may well indicate that cation variation is caused by differing aquifer compositions, a feature which was being sought in that study. Certainly the analyses should be re-evaluated.

The average ionic composition of the groundwater from the Lower Cretaceous rocks is remarkably similar to that of the Anthony Lagoon Beds, as also are some of the samples on the percentage cation and anion graphs. The immediate implication is that these waters are in fact coming from the Anthony Lagoon Beds and not the overlying Cretaceous units. But for most of the samples this is not a tenable explanation, as the bores are not deep enough to have reached the estimated position of the base of the younger sequence; certainly this did not happen in those bores which have been geologically logged. A possible explanation is that water in the Cretaceous aquifers moved upward under pressure from the Cambrian aquifers into the porous and permeable sandstone at the base of the younger sequence. This may also be an explanation of the relatively low static rise encountered in most bores obtaining water from the Lower Cretaceous rocks.

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Reg. No.	Station No. or name	Position	Elevation (m)	Total depth (m)
BEETALOO 1:250 000 SHEET AREA				
316	Newcastle Waters No. 2 (Arabunka)	22 km southeast of Elliott	212	76
471	Elliott No. 2	Elliott Township	221	74
516	Barkly S/R No. 8	0.8 km east of Elliott Township	210	122
517	Barkly S/R No. 7	24 km south-southeast of Elliott	223	175
518	Barkly S/R (Tandyidgee)	42 km southeast of Elliott	216	104
519	Barkly S/R No. 6	61 km southeast of Elliott	215	68
522	Barkly S/R No. 3	22 km west of Eva Downs homestead	210	53
523	Barkly (Eva Downs)	3 km northwest of homestead	216	89
540	Elliott No. 1	Elliott	221	41
541	Town Supply	Elliott	221	95
1056	Ucharonidge No. 2	Old homestead	236	85
1186	Anthony Lagoon No. 24	3 km southwest of Old Shandon Downs homestead	237	—
1187	Anthony Lagoon No. 23	New Shandon Downs homestead	244	—
1233	Beetaloo homestead	Homestead	218	—
1290	Helen Springs No. 10	74 km west of Eva Downs homestead	226	120
1296	Helen Springs No. 16	30 km southeast of New Ucharonidge	232	114
1297	Helen Springs No. 17	29 km south-southeast of New Ucharonidge	239	102
1529	Newcastle Waters No. 6	22 km east by south of Elliott	221	74
1533	Newcastle Waters Lewis Ridge (Tent Pole)	32 km north by east of Elliott	213	88
1534	Newcastle Waters—E Bore	51 km east of Elliott	230	71
1622	Ucharonidge No. 1	6.5 km north by west of homestead	244	100
1623	Ucharonidge No. 3	9.5 km southwest of homestead	244	96
1888	Eva Downs—J. Bore	30 km west by north of homestead	233	108
2165	Anthony Lagoon No. 22	22 km northwest of Eva Downs	223	94
2335	Newcastle Waters Blue-Bush	Lake Woods—Hawker Creek	—	62
2348	Newcastle Waters Orange Tree	21 km east by north of Elliott	215	89
2349	Newcastle Waters Fergusson	Lake Woods—Fergusson Creek	203	88
2351	Newcastle Waters Reg Williams	11 km northeast of Elliott	213	85
2352	Newcastle Waters One Tree	35 km southeast of Elliott	220	100
2353	Newcastle Waters Sweetwater	39 km south-southeast of Elliott	211	78
2380	Beetaloo—Huddleson Lagoon	Huddleson Lagoon on Newcastle Creek	225	82
2381	Beetaloo Martyrs Tree	34 km east-northeast of homestead	220	85
2382	Beetaloo No. 1 (A. Bore)	18 km southeast of homestead	226	88
3148	Anthony Lagoon No. 25	21 km northeast of Eva Downs homestead	230	82
3454	Newcastle Waters Lawson	Lake Woods—near Lawson Creek	201	52
4695	Helen Springs No. 16	31 km southeast of New Ucharonidge	232	106
4707	Anthony Lagoon No. 30	18 km south-southeast of Old Shandon Downs homestead	244	104
4882	Beetaloo—Southern Cross No. 2	16 km north by west of homestead	229	85
4912	Newcastle Waters A. Bore	50 km south-southeast of Elliott	210	59
4913	Newcastle Waters B. Bore	40 km east-southeast of Elliott	224	72
4914	Newcastle Waters C. Bore	35 km east by north of Elliott	230	82
4915	Newcastle Waters D. Bore	48 km east by north of Elliott	239	125
4916	Newcastle Waters Spell Paddock	20 km north by west of Elliott	218	—
4922	Beetaloo Southern Cross No. 1	23 km east-northeast of Beetaloo homestead	218	87
5046	Eva Downs K. Bore	8 km north by east of homestead	226	76
5391	Anthony Lagoon No. 32	10 km northwest of No. 24 (R.N. 1186)	241	94
5432	Ucharonidge No. 4	13 km west by south of Old Ucharonidge	232	77
5433	Ucharonidge No. 5	5 km southeast of New Ucharonidge	242	91
5439	Mungabroom Anthonys	10 km east-northeast of homestead	239	76
5440	House Bore	Mungabroom homestead	245	85
5441	Mungabroom No. 3	2.4 km south by west of Mungabroom Waterhole	—	109
5621		13 km east of Beetaloo homestead	218	94
5683	Ucharonidge No. 6	18 km south-southeast of New Ucharonidge	239	80
5684	Ucharonidge No. 7	New homestead	241	121
DALY WATERS 1:250 000 SHEET AREA				
53	Birdum S/R No. 5	23 km south by west of Daly Waters	233	110
552	Birdum S/R No. 7	35 km south by west of Dunmarra	236	96
555	Birdum S/R No. 4	18 km north of Daly Waters—Roderick Waterhole	197	76
556	Daly Waters Aerodrome	Daly Waters Aerodrome	213	74

Aquifer	Depth of Aquifers (m)	Depth standing water level (m)	Pump depth (m)	Supply l/s	Quality (ppm)	Remarks
Mullaman Beds	55	55	—	—	990	
Cambrian	74	60	69	4.50	—	
Cambrian	91	55	—	3.75	478	
Mullaman Beds or Anthony Lagoon Beds	61	52	62	3.13	872	
Anthony Lagoon Beds	—	53	66	2.00	1324	
Anthony Lagoon Beds?	—	53	60	1.38	1052	
Anthony Lagoon Beds?	44 53	42	—	1.50	1128	
Mullaman Beds	84	45	84	2.00	1186	
—	—	—	—	—	—	
—	73	63	77	—	—	
	95	—	—	2.00	670	
Mullaman Beds?	75	71	79	1.88	2033	
—	—	—	—	—	816	Also known as Shandon No. 1
—	—	—	—	—	975	
	—	—	—	—	669	
Anthony Lagoon Beds	—	—	—	2.13	1546	
Anthony Lagoon Beds?	—	—	—	1.50	—	Abandoned Refer R.N. 4695
Anthony Lagoon Beds?	—	—	82	1.88	1418	
Mullaman Beds?	63	63	—	1.50	572	
Mullaman Beds	69	56	—	1.80	910	
Mullaman Beds	63	63	—	2.25	—	
Anthony Lagoon Beds?	—	73	94	1.13	1245	
—	—	82	85	1.88	789	
Anthony Lagoon Beds	105	66	—	2.25	930	
—	—	—	53	—	1769	
Gum Ridge Formation or Merrina Beds	—	—	—	1.88	—	
Mullaman Beds?	—	—	—	1.80	890	
Gum Ridge Formation?	—	—	67	2.50	—	
Mullaman Beds?	—	—	—	2.06	880	
Mullaman Beds or Anthony Lagoon Beds	—	—	73	2.38	1130	
	—	—	70	2.50	486	
Mullaman Beds	—	—	—	—	—	
Mullaman Beds	—	—	—	—	1554	
—	—	—	—	—	—	
—	—	—	82	2.25	—	
Gum Ridge Formation?	—	—	44	2.00	310	
Anthony Lagoon Beds	—	66	—	2.50	711	Replacement for R.N. 1296
Unconformity between Mullaman	87	87	93	—	—	Also known as Shandon
Beds and Anthony Lagoon Beds	96	—	—	1.50	—	Downs No. 30
Mullaman Beds	78	64	65	1.50	—	
Mullaman Beds or Anthony Lagoon	53	47	55	Unlimited	808	
Beds	55	—	—	—	—	
Anthony Lagoon Beds	58-66	57	63	3.00	404	
Unconformity, Mullaman Beds/ Anthony Lagoon Beds	71	—	76	3.00	—	
Anthony Lagoon Beds	—	—	112	1.88	—	
—	—	—	—	—	475	
Mullaman Beds	64	61	79	—	—	
	82-87	—	—	0.98	Good	
Mullaman Beds?	—	—	—	—	—	
Anthony Lagoon Beds	80 86 92	76	—	1.50	Good	
Mullaman Beds	72	72	—	2.50	453	
Mullaman Beds?	64	64	85	1.88	2021	
—	—	—	—	1.75	—	
—	—	—	—	2.50	—	
—	—	—	—	1.88	—	
Mullaman Beds	58	57	—	0.25	Good	
Mullaman Beds?	68	68	74	1.88	—	
Mullaman Beds or Anthony Lagoon Beds	—	76	112	2.50	1392	
Tindall Limestone	84	84	106	1.19	1562	Abandoned. See R.N. 557
Mullaman Beds or Tindall Limestone	—	76	79	0.68	1187	Abandoned. See R.N. 2264
Mullaman Beds or Tindall Limestone	—	47	51	1.88	1355	
Tindall Limestone?	—	61	67	—	1824	

Reg. No.	Station No. or name	Position	Elevation (m)	Total depth (m)
DALY WATERS (continued)				
557	Birdum S/R No. 5	23 km south by west of Daly Waters	233	105
559	Birdum S/R No. 6	At Dunmarra	231	100
582	Murranji S/R 10A	51 km southwest of Dunmarra	230	84
586	Murranji S/R No. 13	37 km south by east of New Birrimba homestead	276	171
587	Murranji S/R No. 12	47 km southeast by south of New Birrimba homestead	280	189
588	Murranji S/R No. 11	64 km southeast of New Birrimba homestead	260	185
589	Murranji S/R, Murranji Waterhole Bore	Murranji Waterhole	244	179
590	Murranji S/R No. 10	2 km east of 10A (R.N. 582)	229	183
636	Dunmarra No. 1 Drought Relief	10 km southwest of Dunmarra	232	90
908	Murranji S/R No. 14 (Pussycat)	39 km south of Nelly Waterhole	220	80
1464	Army Bore 618	5 km south of Daly Waters	—	77
1465	Army Bore 620	13 km south of Daly Waters	—	107
1466	Army Bore 622	68 km south of Daly Waters (Johnson's Lagoon)	c. 228	86
1982	Hidden Valley Bore	3.2 km northwest of homestead	235	113
1989	Dry River S/R No. 8	Not located	—	113
2263	Dunmarra No. 3	3.2 km west of Frew Pond	232	91
2264	Birdum S/R No. 7	—	236	—
2529	Dry River S/R No. 8	72 km northeast Top Springs Not located	—	68
2778	Daly Waters station Kallala Bore	Kallala homestead 6 miles north-northwest of Daly Waters	207	63
4518	Widgee Bore	New Birrimba homestead	209	55
4529	Daly Waters station Moorak	13 km north of Kallala homestead	206	67
4596	A.I.B. Johnsons	Johnsons Lagoon—18 km south of Dunmarra Roadhouse	—	—
5395	Daly Daters station Enoa Noa	13 km northeast by north of Daly Waters	200	57
5425	Dry River S/R No. 8	16 km north of Nelly Waterhole	238	277
5760	C.C.A.	8 km east of Stuart Highway on Daly Waters-Borroloola Road	229	82
	House Bore	Daly Waters station	—	—
	Natural Well	18 km south by west of Hidden Valley homestead	251	—
DELAMERE 1:250 000 SHEET AREA				
1346	Delamere No. 6 Well	Homestead	105	18
1349	Delamere No. 4 Georges Bore	Georges Creek—24 km south-southwest of homestead	c. 138	22
1350	Willeroo No. 2 Well	—	—	64
1351	Willeroo No. 3	At Willeroo homestead	162?	70
1352	Willeroo No. 4 Well	—	—	71
1353	Willeroo No. 5 Well	—	—	—
1354	Willeroo No. 14 Well	Near Mount Leonard	—	—
1355	Willeroo No. 1 Nemo Bore	—	—	32
2210	Coolibah S/R Camp Oven Bore	—	c. 152	51
3546	House Bore	Willeroo homestead	162	25
3766	Delamere No. 5 Site 2	24 km south-southeast of homestead	168	61
4029	—	10 km east of Delamere homestead	180	—
4488	Willeroo—Horse Paddock Bore	13 km southwest of homestead	183?	101
4792	Delamere No. 2 Site 3	16 km east by south of homestead	197	46
4793	Delamere No. 3 Site 6	8 km north-northwest of Tinker Hill	189	61
5402	Willeroo Beef Road No. 3	Near Mount Leonard	162	79
5421	House Bore	Delamere homestead	126	150
5437	Willeroo Beef Road No. 4	Humbles Creek	191	31
5459	Delamere Station	10 km south of homestead	181	152
5460	Delamere Station	8 km north-northeast of homestead	138	152
5469	Willeroo Beef Road No. 5	27 km south by east of Willeroo homestead	259	45
5470	Willeroo Beef Road No. 5	—	259	76
5471	Delamere 10/32	5 km southwest of homestead	110	100
5496	Willeroo Beef Road D.W.H. N. 2	19 km east by north of Delamere homestead	247	183

Aquifer	Depth of Aquifers (m)	Depth standing water level (m)	Pump depth (m)	Supply l/s	Quality (ppm)	Remarks
Tindall Limestone	82	79	—	1.88	1337	
Mullaman Beds or Tindall Limestone	—	84	87	1.88	—	
Merrina Beds?	73-84	71	80	1.81	—	
Antrim Plateau Volcanics or Montejinni Limestone	152	108	110	1.88	454	
Merrina Beds/Montejinni Limestone	139 186	119	132	1.88	485	
Merrina Beds	167	113	115	1.25	488	
Merrina Beds	—	88	107	3.75	303	
Mullaman Beds or Merrina Beds	131	76	91	1.13	2117	
Mullaman Beds?	—	—	82	1.80	—	
Montejinni Limestone	—	36	44	1.50	456	
—	—	—	—	—	—	Not located
—	—	—	—	0.88	—	Not located
—	—	—	—	0.13	—	Not located
Montejinni Limestone, or Antrim Plateau Volcanics	—	83	—	—	426	
—	—	—	—	—	—	See R.N. 2529 and R.N. 5425. 1st attempt, dry hole, hard drilling, abandoned
—	—	—	—	—	—	
—	—	—	—	—	920	See R.N. 552
—	—	—	—	—	—	See R.N. 1989 and 5425. 2nd attempt—dry
Tindall Limestone	59	57	—	1.88	—	
Montejinni Limestone	47	45	49	0.94	407	
Tindall Limestone below unconformity with Mullaman Beds	60 63-67	60	—	2.25	Fair	
—	—	—	—	—	—	Not located
Tindall Limestone	52-57	52	—	1.50	1193	
Antrim Plateau Volcanics	181	100	—	0.07	—	
	220	73	—	0.50	1457	
	268	70	—	1.00	—	
Unconformity. Mullaman Beds and Tindall Limestone	68	76	—	1.50	—	
—	—	—	—	—	1338	Old Army Bore R.N. unknown
Mullaman Beds	—	6	7	1.00	20	
—	—	9	—	—	371	Not equipped
Antrim Plateau Volcanics	—	—	—	—	—	
—	—	—	—	—	—	
Antrim Plateau Volcanics	—	—	—	—	—	
—	—	—	—	—	—	
—	—	—	—	—	—	Caved in
—	—	—	—	—	—	Not located
—	—	—	—	—	—	Now dry
Tindall Limestone?	—	34	43	0.88	—	
Antrim Plateau Volcanics	20	5	—	—	—	
	23	—	—	—	—	
	25	—	—	—	—	
Antrim Plateau Volcanics?	40	43	—	1.00	—	
	49	—	—	1.62	—	
	61	—	—	2.50	—	
—	—	—	—	—	—	Dry
Antrim Plateau Volcanics	29	9	—	0.18	492	
	41	9	—	1.19	—	
	98	20	—	—	—	
Antrim Plateau Volcanics	43	30	—	—	325	
Antrim Plateau Volcanics	55	49	—	2.25	—	
Antrim Plateau Volcanics	4 47 66-67	3	—	1.25	397	
Victoria River Group	145	5	—	7.50	616	
Antrim Plateau Volcanics	3 8 24	3	—	2.13	—	
Antrim Plateau Volcanics	82	31	—	0.15	218	Insufficient supply
Victoria River Group	143	11	—	0.45	—	
Antrim Plateau Volcanics	42	26	—	—	—	Approx. 15 m east of R.N. 5945
—	26	—	—	—	—	1st attempt at R.N. 5469. Both replaced by R.N. 5945
Victoria River Group	94	9	—	—	—	
Montejinni Limestone (Middle Unit)	31	22	—	0.38	—	

Reg. No.	Station No. or name	Position	Elevation (m)	Total depth (m)
DELAMERE (continued)				
5522	Delamere Horse Spring Creek	1.6 km south of Johnstone Waterhole on Gregory Creek	131	90
5543	Delamere 1022	5 km east-southeast of homestead	180	186
5544	Willeroo Beef Road D.W.H. No. 3	37 km at 109° from Delamere homestead	219	178
5545	Willeroo Beef Road D.W.H. No. 4	11 km south of D.W.H. No. 1	267	125
5546	Willeroo Beef Road D.W.H. No. 5	29 km at 95° from Delamere homestead	230	100
5547	Delamere Queuing Pen Bore	10 km northeast of homestead	139	18
5551	Delamere 6 mile Yard Bore	10 km south by west of Tinker Hill	166	53
5554	Delamere Freds Yard Bore	26 km southeast of homestead	162	113
5610	Delamere Bullock Yard	34 km southeast of homestead	c. 152	136
5945	Willeroo Beef Road D.W.H. No. 1	12 km at 160° from Willeroo homestead	259	137
FERGUSSON RIVER 1:250 000 SHEET AREA				
5007	Scott's Creek No. 1	68 km southwest of Katherine on Willeroo Road	c. 122	137
HELEN SPRINGS 1:250 000 SHEET AREA				
103	Helen Springs No. 2	37 km north by east of homestead	203	87
104	Helen Springs No. 3	34 km north-northeast of homestead	213	82
105	Helen Springs No. 4	43 km west-southwest of Eva Downs homestead	225	89
108	Helen Springs No. 7	16 km north of homestead	224	70
127	Banka Banka No. 1	42 km north-northwest of Brunchilly homestead	222	66
134	Banka Banka No. 8	29 km north-northwest of Brunchilly homestead	228	79
140	Rockhampton No. 8	47 km east by south of Brunchilly homestead	219	64
180	Banka Banka No. 7	34 km east-northeast of homestead	236	96
192	Banka Banka No. 2	24 km north by west of Brunchilly	227	91
219	Helen Springs No. 5	68 km west-southwest of Eva Downs homestead	223	98
229	Banka Banka No. 3	23 km east-northeast of homestead	253	89
237	Rockhampton No. 15	18 km northeast of Brunchilly Dam	212	57
313	Banka Banka No. 5	40 km north by west of Brunchilly homestead	217	85
376	Banka Banka No. 6	32 km north by west of Brunchilly homestead	219	58
380	Banka Banka No. 4	18 km north of Brunchilly homestead	226	81
381	Helen Springs No. 1	21 km northeast of homestead	233	85
393	Helen Springs No. 6	64 km south-southwest of Eva Downs homestead	219	92
410	Rockhampton No. 16	6 km southeast of Coolunjie Waterhole	210	63
418	North-South S/R (Jingerah)	27 km north by east of Helen Springs homestead	221	104
419	North-South S/R (Helen Springs)	1.6 km east of Helen Springs homestead	283	19
420	North-South S/R (Muckety)	2 km east of Muckety homestead	287	18
421	North-South S/R (Banka Banka)	3 km east by south of Banka Banka homestead	292	23
520	Barkly S/R No. 5	4 km east of Monmoona Creek	215	87
521	Barkly S/R No. 4	45 km west of Eva Downs homestead	230	82
702	Muckety Ladabah	24 km west-northwest of homestead	251	22
927	North-South S/R Banka Banka	3 km east by south of Banka Banka homestead	292	23
928	Powell Creek station well	Powell Creek station	233	12
979	North-South S/R Renner Springs	Near Mount Castle	—	167
1193	Banka Banka No. 10	Carmilly Creek—32 km north-northeast of homestead	220	66
1194	Banka Banka No. 9	1.6 km north of homestead	297	37
1198	Brunchilly No. 1	Homestead	237	93

Aquifer	Depth of Aquifers (m)	Depth standing water level (m)	Pump depth (m)	Supply l/s	Quality (ppm)	Remarks
Antrim Plateau Volcanics and	11	8	—	0.69	—	
Victoria River Group	27	8	—	0.88	—	
	34	8				
Antrim Plateau Volcanics and	47	30	—	0.45	—	Not equipped
Victoria River Group	140					
Antrim Plateau Volcanics	41	29	—	1.13	391	
	124	29	—	1.80		
	129	29	—	2.00		
Antrim Plateau Volcanics	31	24	—	1.13	—	
	108	18	—	1.50	—	
Antrim Plateau Volcanics	39	33	—	0.19	—	
	82	27	—	3.00	—	
Antrim Plateau Volcanics	12	7	—	5.00	—	
Antrim Plateau Volcanics	43	?	?	?	—	
	47	27	—	0.50	—	
	49	6	—	2.50	—	
Antrim Plateau Volcanics	38	7	—	0.77	—	
	78	—	—	—	—	
Antrim Plateau Volcanics	46	9	—	0.50	—	
	130	8	—	0.75	—	
Antrim Plateau Volcanics	39	30	—	0.30	—	
	135	?	—	0.30	—	
	137	27	—	4.50	—	
Jinduckin Formation	15	5	10	2.00	Fair	
	20					
	23					
	26-38					
Anthony Lagoon Beds?	—	53	—	0.98	—	
Anthony Lagoon Beds	73	52	62	—	1079	
	82	—	—	1.44	—	
Anthony Lagoon Beds	—	55	76	1.50	—	
Helen Springs Volcanics	—	67	67	1.00	780	
or Tomkinson Creek Beds						
Anthony Lagoon Beds?	60	57	—	3.75	1460	
Anthony Lagoon Beds	69	63	75	1.50	1271	
or Gum Ridge Formation						
Anthony Lagoon Beds	—	44	—	Good	4583	
Anthony Lagoon Beds?	83	61	94	2.50	—	
Anthony Lagoon Beds	66	—	69	0.30	1371	
	89	59	—	1.50		
Anthony Lagoon Beds	—	54	67	1.25	656	
Gum Ridge Formation or	77	76	—	0.63	—	
Tomkinson Creek Beds						
Anthony Lagoon Beds	41-47	44	49	Good	2255	
Anthony Lagoon Beds	64-73	—	—	Good	—	
Anthony Lagoon Beds	53	46	48	2.25	—	
Anthony Lagoon Beds	64	64	—	0.63	—	
Anthony Lagoon Beds	—	76	79	1.75	384	
Anthony Lagoon Beds	—	52	82	2.38	—	
Anthony Lagoon Beds	—	47	53	Good	2302	
Anthony Lagoon Beds	50	47	58	2.00	410	
	82					
Helen Springs Volcanics	—	10	16	3.75	447	
Helen Springs Volcanics	—	5	15	Good	929	
Helen Springs Volcanics	—	—	—	Poor	—	Abandoned
						See R.N. 927
Anthony Lagoon Beds	62	53	59	0.69	701	
Anthony Lagoon Beds	72	62	76	—	1498	Original bore 114 m
	81	—	—	2.00		
Tomkinson Creek Beds?	21-22	18	—	0.88	2520	
Helen Springs Volcanics	—	15	—	0.52	700	Replacement for R.N. 421
Tomkinson Creek Beds	—	4	—	—	—	
Tomkinson Creek Beds	20	—	—	—	—	Abandoned
Anthony Lagoon Beds	—	—	64	—	1085	
Helen Springs Volcanics?	—	—	—	1.25	481	
Anthony Lagoon Beds	87	—	—	1.88	—	

Reg. No.	Station No. or name	Position	Elevation (m)	Total depth (m)
HELEN SPRINGS (continued)				
1199	Brunchilly No. 2	18 km east by south of homestead	229	77
1202	Brunchilly No. 5	19 km northeast of homestead	232	69
1203	Brunchilly No. 6	34 km east by south of homestead	224	110
1204	Brunchilly No. 7	32 km east-northeast of homestead	219	93
1205	Brunchilly No. 8	34 km northeast of homestead	213	69
1206	Brunchilly No. 9	45 km north-northeast of homestead	210	85
1286	Helen Springs homestead well	Homestead	—	6
1287	Helen Springs garden well	Homestead	—	9
1288	Helen Springs No. 8	51 km west-southwest of Eva Downs homestead	210	63
1289	Helen Springs No. 9	60 km southwest of Eva Downs homestead	c. 213	99
1291	Helen Springs No. 11	32 km northeast of homestead	213	98
1292	Helen Springs No. 12	23 km east-northeast of homestead	223	86
1293	Helen Springs No. 13	40 km east of homestead	c. 213	136
1294	Helen Springs No. 14	51 km east-northeast of homestead	210	88
1295	Helen Springs No. 15	11 km south of Monmoona Waterhole on Barkly S/R	207	72
1505	Muckety station	—	—	—
2230	Rockhampton No. 23	23 km southeast of Brunchilly Dam	224	—
2231	Rockhampton No. 24	8 km east-northeast of Brunchilly Dam	213	—
2327	Eva Downs—A. Bore	8 km west-southwest of homestead	207	78
2328	Eva Downs—B. Bore	27 km west-southwest of homestead	212	71
2329	Eva Downs—C. Bore	10 km south-southwest of homestead	218	80
2330	Eva Downs—D. Bore	42 km southwest of homestead	204	47
2331	Eva Downs—E. Bore	26 km south of homestead	203	50
2332	Eva Downs—F. Bore	16 km south-southwest of homestead	207	49
2333	Eva Downs—G. Bore	50 km southwest of homestead	203	51
2334	Eva Downs—H. Bore	26 km southwest of homestead	**209**	**66**
4141	Muckety homestead	Near homestead	—	44
4286	Brunchilly No. 10	48 km northeast of homestead	207	50
4305	Banka Banka No. 12	49 km northeast of homestead	225	86
4457	Helen Springs No. 20	29 km east by north of homestead	c. 213	80
4500	Helen Springs No. 21	13 km southwest of No. 4 Barkly Stock Route (R.N. 521)	c. 213	75
4519	Brunchilly No. 15	8 km east-southeast of homestead	238	76
4521	Brunchilly No. 3	47 km north-northeast of homestead	206	69
4522	Brunchilly No. 4	29 km north-northeast of homestead	223	76
4569	Muckety No. 1	10 km northwest of homestead	268	74
4601	Helen Springs No. 18	0.8 km southeast of Maryville	—	—
4602	Helen Springs No. 19	5 km north by east of homestead	273	50
4667	Muckety homestead	Homestead	287	107
4803	North-South S/R Junction Reserve	Junction North-South and Barkly S/Rs	209	104
5671	Banka Banka No. 11	37 km northeast of homestead	223	76
5672	Banka Banka No. 13	16 km north-northwest of Brunchilly homestead	229	75
5673	Banka Banka No. 14	6 km southeast of homestead	295	36
5674	Banka Banka No. 15	23 km northeast of homestead	245	95
5675	Banka Banka No. 17	8 km north of Munkaderry Waterhole on Attack Creek	219	61
5676	Banka Banka No. 18	47 km north of Brunchilly homestead	222	40
5677	Banka Banka—No Hope Bore	Homestead	297	21
5678	Eva Downs—I. Bore	Homestead	**216**	**201**
5679	Eva Downs—L. Bore	40 km south of homestead	201	43
5680	Eva Downs—M. Bore	40 km south-southwest of homestead	203	50
5681	Eva Downs—N. Bore	About 19 km southwest of homestead	—	105
5682	Eva Downs—O. Bore	18 km south by east of homestead	206	58
5794	Banka Banka No. 16	19 km southeast of homestead on Morphett Creek	268	32
	Wiggenty Well	5 km north by east of Muckety No. 1 (R.N. 4569)	287	—
HODGSON DOWNS 1:250 000 SHEET AREA				
644	Nutwood Downs No. 4	16 km west of homestead	192	24
645	Nutwood Downs No. 5	35 km southwest of homestead	c. 198	69
646	Nutwood Downs No. 6	20 km south-southwest of homestead	177	34
877	Nutwood Downs No. 7	10 km southeast of homestead	c. 183	12
878	Nutwood Downs No. 8	13 km southeast of homestead	189	21
881	Nutwood Downs No. 11	13 km west by south of homestead	171	16
1485	Nutwood Downs No. 2	18 km southeast of homestead	183	23
1486	Nutwood Downs No. 1	21 km south-southeast of homestead	174	39
1487	Nutwood Downs No. 3	13 km west of homestead on Mickey Creek	183	27
	Nutwood Downs N.D. Bore	24 km west by north of homestead	c. 177	128
2878	Nutwood Downs station well	Homestead	—	—
4883				

Aquifer	Depth of Aquifers (m)	Depth standing water level (m)	Pump depth (m)	Supply l/s	Quality (ppm)	Remarks
Anthony Lagoon Beds	70	—	—	1.50	1110	
Anthony Lagoon Beds	63	—	—	1.50	2801	
Anthony Lagoon Beds	67	40	—	—	3487	
Anthony Lagoon Beds	82	—	—	1.75	7320	
Anthony Lagoon Beds	61	—	—	1.75	2590	
Anthony Lagoon Beds	37	—	—	1.75	3596	
Helen Springs Volcanics	—	3	—	—	—	
Helen Springs Volcanics	—	6	9	—	—	
Anthony Lagoon Beds	—	—	—	1.50	1273	
Anthony Lagoon Beds	—	—	—	—	1978	
Anthony Lagoon Beds	—	—	—	3.00	1211	
Anthony Lagoon Beds?	—	—	64	1.25	—	
Anthony Lagoon Beds?	—	—	c. 88	1.88	1758	
Anthony Lagoon Beds	—	—	—	—	1097	
Anthony Lagoon Beds	—	—	—	1.88	284	
—	—	—	—	—	—	
Anthony Lagoon Beds	—	—	—	—	—	
Anthony Lagoon Beds	—	—	—	—	—	
Anthony Lagoon Beds	—	—	—	2.25	1492	
Anthony Lagoon Beds	—	—	—	2.25	1181	
Anthony Lagoon Beds	—	61	—	—	458	
Anthony Lagoon Beds	—	—	—	—	781	
Anthony Lagoon Beds	—	—	—	—	471	
Anthony Lagoon Beds	—	—	—	2.25	474	
Anthony Lagoon Beds	—	—	—	—	690	
Anthony Lagoon Beds	—	—	—	2.25	577	
—	—	—	—	—	—	Dry
Anthony Lagoon Beds	—	—	—	1.75	2993	
Anthony Lagoon Beds	—	—	—	1.25	2375	
—	—	60	—	1.50	1382	
Anthony Lagoon Beds	—	53	59	1.50	—	
Anthony Lagoon Beds	—	73	—	1.38	—	
Anthony Lagoon Beds	—	62	—	—	711	
Anthony Lagoon Beds	—	—	70	1.31	3417	
Tomkinson Creek Beds	67	27	49	1.00	Good	
Helen Springs Volcanics or Tomkinson Creek Beds	—	—	—	—	364	
Helen Springs Volcanics?	—	—	46	1.50	294	
Helen Springs Volcanics	9 58	9	58	0.52	864	
—	82	47	—	2.00	384	
—	—	64	67	—	1400	
Anthony Lagoon Beds	75	—	—	—	—	
Tomkinson Creek Beds	—	—	—	—	—	Abandoned
Tomkinson Creek Beds	79	—	79	—	—	
Anthony Lagoon Beds	—	—	—	—	2528	
Anthony Lagoon Beds	—	—	—	—	—	
Tomkinson Creek Beds	4-10 18-21	2	—	1.88	—	
Anthony Lagoon Beds	—	—	—	—	821	
Anthony Lagoon Beds	—	26	—	—	332	
Anthony Lagoon Beds	29	—	—	—	440	
Anthony Lagoon Beds	25	—	—	.006	Salty	Never equipped
	58	—	—	0.13	—	Abandoned
	94-105	—	—	0.25	—	
Anthony Lagoon Beds	42	48	—	—	449	
	46	—	—	—	—	
	55	—	—	2.25	—	
Tomkinson Creek Beds	27	c. 27	c. 32	—	—	Abandoned
	32	—	—	—	—	
Tomkinson Creek Beds	—	3	—	—	288	
Nutwood Downs Volcanics	—	—	—	—	—	Dry hole
Tindall Limestone?	68	52	—	1.38	—	
Tindall Limestone?	—	—	—	1.80	—	
Nutwood Downs Volcanics	—	—	—	—	—	Abandoned owing to hard drilling
Probably Roper Group	—	—	—	0.68	—	
Nutwood Downs Volcanics	—	—	—	—	—	Abandoned owing to hard drilling
Probably Roper Group	—	—	—	Good	—	
Nutwood Downs Volcanics	—	—	—	—	—	Dry hole
Nutwood Downs Volcanics	—	—	—	—	—	Dry hole
Nutwood Downs Volcanics	—	—	—	2.50	—	
Nutwood Downs Volcanics	—	—	—	—	—	

Reg. No.	Station No. or name	Position	Elevation (m)	Total depth (m)

KATHERINE 1:250 000 SHEET AREA

Reg. No.	Station No. or name	Position	Elevation (m)	Total depth (m)
64	—	10 km south of Mataranka homestead	140	22
131	Army No. 474	Near Mataranka township	135	35
148	Tindall Aerodrome	—	137	20
150	—	—	—	35
154	—	Roper Creek: 23 km southwest of Maranboy Siding	152	55
159	—	5 km east-southeast of Katherine	110	35
309	—	3 km east of Manbulloo homestead	104	39
312	—	1.6 km east of Manbulloo homestead	104	28
314	—	5 km south of Mataranka	140	22
325	—	3 km southwest of Manbulloo homestead	98	63
406	—	Manbulloo Aerodrome	122	70
407	—	Manbulloo Aerodrome	59	70
408	—	Northeast of Tindall Aerodrome	130	21
409	—	Tindall Aerodrome	130	21
596	—	Abattoirs railhead	c. 104	37
660	—	Beswick homestead	152	123
661	—	—	—	37
1439	—	3 km northwest of Katherine	107	34
1440	—	10 km northwest of Katherine	125	26
1441	—	3 km northwest of Katherine near R.N. 1439	107	27
1442	—	Near Katherine Aerodrome	107	27
1443	—	Near low-level crossing, Katherine	104	63
1444	—	Near Katherine Aerodrome	107	61
1445	—	—	—	61
1447	—	Katherine township	104	35
1448	—	Katherine township	104	25
1450	—	Near Tindall Aerodrome	130	18
1451	—	39 km southeast of Katherine	169	62
1452	—	Maranboy Siding	162	76
1453	—	14 km east-southeast of Maranboy Siding	160	55
1454	—	6 km northwest of Mataranka	139	41
1821	—	13 km south-southwest of Beswick homestead	152	34
1827	—	14 km northwest of Katherine	134	35
1900	—	14 km west of Kowai Lagoon	137	26
1901	Dry River Stock Route No. 1	24 km south of Katherine	140	183
1950	—	—	—	26
1987	—	14 km west of Mataranka	189	61
1999	—	—	—	24
2522	—	Near R.N. 159	110	47
2719	—	Venn Airfield	175	58
2720	—	Venn Airfield	175	61
2721	—	1.6 km southeast of Venn	—	48
2722	—	1.6 km northwest of Venn	—	18
2723	—	3 km northwest of Venn	—	26
2902	—	16 km northwest of Katherine	134	60
3025	—	Tindall Aerodrome	130	12
3027	—	Tindall Aerodrome	130	4
3032	—	Northwest of Venn Aerodrome	168	64
3544	—	Mataranka homestead	134	30
3547	—	—	—	91
4077	—	0.8 km east of Tindall Aerodrome	137	33
4143	—	0.8 km east of Tindall Aerodrome	137	43
4159	—	East of Beswick homestead	—	—
4160	—	Northern end of Beswick old aerodrome	—	—
4278	4-mile Farm No. 2	Katherine	113	61
4281	15-mile Farm, 1st attempt	14 km northwest of Katherine near R.N. 1827	134	71
4282	—	5 km east-southeast of Katherine near R.N. 159	110	55
4379	15-mile Farm, 2nd attempt	14 km northwest of Katherine	134	125
4420	—	3 km southeast of Katherine	107	37

Aquifer	Depth of Aquifers (m)	Depth standing water level (m)	Pump depth (m)	Supply l/s	Quality (ppm)	Remarks
Tindall Limestone	5	5	—	2.00	—	
Tindall Limestone	25-26	11	—	1.75	—	
	29-31	11				
Tindall Limestone	—	14	—	1.88	—	
Tindall Limestone	16	16	—	2.13	—	
	30					
Tindall Limestone	30-34	30	—	—	—	
	35-40	30	—	2.25	—	
Tindall Limestone	—	8	—	2.25	—	
Jinduckin Formation	17	17	—	2.50	—	
Tindall Limestone?	27					
Tindall Limestone?	33					
Jinduckin Formation?	12	9	—	1.00	—	
	18	7	—	0.50	—	
	25	3	—	0.50	—	
	28	Flowing	—	5.00	—	
Tindall Limestone	13-19	8	—	1.15	—	
	20-21					
Jinduckin Formation?	40-58	18	—	0.56	—	
	59-63					
Jinduckin Formation	—	—	—	0.90	—	
Jinduckin Formation	—	—	—	0.90	—	
Tindall Limestone	—	16	—	1.25	—	
Tindall Limestone	—	13	—	1.88	—	
Tindall Limestone	21	21	—	0.94	—	
Mount Rigg Group	—	—	—	0.13	—	
—	7	—	—	0.75	—	
	16					
	37					
Tindall Limestone	—	—	—	2.50	—	
Tindall Limestone	—	—	—	2.50	—	
Tindall Limestone	—	—	—	5.00	—	
Tindall Limestone?	—	—	—	3.50	—	
Tindall Limestone	—	16	—	7.50	—	
Tindall Limestone?	—	—	—	1.88	—	
—	—	9	—	1.88	—	
Tindall Limestone	16	16	—	2.13	—	
	30	—				
Tindall Limestone	—	—	—	1.88	—	
Tindall Limestone	—	—	—	1.88	—	
Tindall Limestone	—	—	—	2.25	—	
Tindall Limestone	—	—	—	1.00	—	
Tindall Limestone	30-46	31	—	1.50	—	
	52-55	31				
Tindall Limestone	—	—	—	3.75	—	
Antrim Plateau Volcanics or Mount Rigg Group	34	11	—	1.50	—	
Mullaman Beds or Tindall Limestone	—	31	—	1.62	Total h'dness 430	
Oolloo Limestone?	21	16	—	1.45	—	
Tindall Limestone?	168-183	—	—	0.75	2404	
—	21	16	—	2.20	—	Maybe 1900
Tindall Limestone	54	54	—	1.82	—	
	59	52	—			
—	—	16	—	5.00	—	
Tindall Limestone	19	16	—	31.25	—	
—	—	—	—	—	—	Dry hole
—	—	—	—	—	—	Dry hole
—	—	—	—	—	—	Dry hole
—	—	—	—	—	—	Dry hole
—	—	—	—	—	—	Dry hole
Tindall Limestone	58	53	—	2.25	331	
Tindall Limestone	—	—	—	—	337	
Tindall Limestone	—	—	—	—	434	
Tindall Limestone	58	54	—	2.25	—	
	64	54				
Tindall Limestone	1-30	5	—	1.88	—	
Burrell Creek Formation	64	17	—	0.15	—	
	81-84	17	—	0.15-0.27	Total h'dness	
	87-88	17	—	0.90-1.00	39	
Tindall Limestone	20	17	—	6.00	—	
Tindall Limestone	37	17	—	3.00	Total h'dness	
	41	17	—	7.25	345	
Alluvium over Mount Rigg Group	18	—	—	0.69	—	
Dook Creek Formation	—	—	—	—	—	Dry hole
Antrim Plateau Volcanics	27	12	—	0.02	Good	
Tindall Limestone	61	57	—	0.23	Good	
Tindall Limestone	28	15	—	0.15	—	
Antrim Plateau Volcanics	41	14	—	0.38	—	
Antrim Plateau Volcanics	50	15	—	0.50	—	
Tindall Limestone	117	50	—	0.02	Good	
Tindall Limestone	18	18	—	5.63	—	
	37	18				

Reg. No.	Station No. or name	Position	Elevation (m)	Total depth (m)
KATHERINE (continued)				
4523	C.S.I.R.O. Farm	8 km south of Katherine 0.4 km east of road	113	39
4524	Soccer Bore No. 1	Katherine sports oval	104	26
4525	Soccer Bore No. 2	Katherine sports oval	104	32
4600	Tindall Airstrip No. 3	Tindall aerodrome Northern end of airstrip	130	46
4627	—	16 km northwest of Katherine near R.N. 2902	134	47
4648	Tindall Airstrip No. 5	Tindall aerodrome	130	24
4709	—	Near R.N. 4077	137	32
4859	Katherine Water Supply No. 2	Nixons Crossing near R.N. 4918	107	9
4881	—	Katherine Showground	104	35
4886	Katherine Water Supply	Nixons Crossing	107	10
4918	Katherine Water Supply	Nixons Crossing	107	11
5012	Manbulloo King River No. 1	32 km southwest of Katherine on Willeroo road	91	43
5019	Katherine No. 1	1.6 km upstream from Nixons Crossing	c. 107	9
5020	—	1.6 km upstream from Nixons Crossing	107	5
5032	15-mile Farm No. 6	1.6 km south-southwest of farm buildings	130	61
5042	15-mile Farm No. 7	—	125	46
5082	—	—	—	61
5148	Mataranka 47/65, 2nd attempt	26 km southeast of Katherine	165	59
5150	Mataranka 40/65	26 km southeast of Maranboy Siding	c. 168	61
5151	Mataranka 47/65, 1st attempt	26 km southeast of Katherine	165	61
5178	5-mile Creek No. 1	Northeast of Katherine	107	29
5329	Tindall Married Quarters	Tindall Aerodrome	130	36
5435	Dry River S/R No. 2	Kowai Lagoon	110	64
5438	Mataranka 35/65	East-northeast of Mataranka homestead	—	107
5705	Mataranka Town No. 2	Mataranka	135	20
LARRIMAH 1:250 000 SHEET AREA				
89	Army Bore No. 530B	536 km from Darwin—vicinity Larrimah township	c. 194	62
107	Army Bore No. 481	Gorry area	—	—
136	Army Bore No. 583	Gorry area	—	—
137	Army Bore No. 589	Gorry area	—	59
138	Army Bore No. 584	Gorry area	—	—
	R.A.A.F. 587	Gorry area	—	67
141	Army Bore No. 522	14 km north of Old Gorrie homestead	177	52
142	Army Bore No. 591	Gorry area	—	64
143	Army Bore No. 582	Gorry area	—	65
146	Army Bore No. 588	Gorry area	—	75
152	Army Bore No. 585	Gorry area	—	—
307	Army Bore No. 394	Gorry area	—	61
311	Army Bore No. 386	Birdum	—	65
319	Army Bore No. 531	16 km east by north of Birdum	—	57
320	Army Bore No. 532	6 km south by east of Larrimah?	783	53
326	R.A.A.F. 527	—	—	—
346	Army Bore No. 528	183 m west ot 336-mile Peg	—	—
416	Gorry R.A.A.F. 590	—	—	67
550	Birdum S/R No. 1	21 km north-northwest of Larrimah	166	39
551	Larrimah No. 2	Near police station	194	79
553	Birdum S/R No. 2	6 km south by east of Larrimah	180	46
554	Birdum S/R No. 3	Ironstone Creek Waterhole on Birdum Creek	186	58
558	Town Bore	Birdum	181	68
902	Dry River S/R No. 3	77 km west of Elsey Cemetery	151	69
903	Dry River S/R No. 4	Road crossing of Dry River	154	75
904	Dry River S/R No. 5	1.6 km west of Dry River homestead	166	117
905	Dry River S/R No. 6	21 km north of Old Birrimba homestead	192	162

Aquifer	Depth of Aquifers (m)	Depth standing water level (m)	Pump depth (m)	Supply l/s	Quality (ppm)	Remarks
Tindall Limestone	27	19	—	0.27	453	
	32	19	—	0.65	—	
	39	19	—	3.00	—	
Tindall Limestone	24	15	—	1.25	524	
	9	15	—	1.38	—	
Tindall Limestone	29	12	—	1.62	568	
Tindall Limestone	21	17	—	2.25	428	
	37	17				
Tindall Limestone	—	4	—	1.50	—	
Tindall Limestone	18	17	—	2.00	—	
Tindall Limestone	20	17	—	2.19	518	
Alluvium over Burrell Creek Formation	3	2	—	4.25	Good	
Tindall Limestone	19	13	—	1.25	—	
	27	13				
	30	13				
Alluvium	3-10	3	—	9.75	409	
Alluvium	3-11	3	—	11.00	—	
Oolloo Limestone	27	24	—	0.81	Good	
	38	24				
	41	24				
Alluvium over Burrell Creek Formation	3	3	—	0.06	—	
Alluvium over Burrell Creek Formation	2	0.9	—	0.06	—	Abandoned
Jinduckin Formation or Tindall Limestone	59	47	—	6.00	—	
Jinduckin Formation?	23	33	—	2.25	442	
	41	33				
	45	33				
—	—	—	—	—	417	
Mullaman Beds	54	49	—	0.94	330	
Unconformity Mullaman Beds Tindall Limestone	42	36	—	2.50	Good	
Tindall Limestone	54	54	—	0.13	Good	Hole abandoned, drilling difficulties
Antrim Plateau Volcanics	18	11	—	1.00	—	
Tindall Limestone	18-24	18	—	6.25	—	
	30-34	18				
—	—	40	—	—	—	Abandoned
Adelaidean	—	—	—	—	—	Seepage only
Tindall Limestone	17-18	11	—	2.13	Fair	
Tindall Limestone	55	56	—	1.44	—	Not located
	61					
—	—	—	—	0.90	—	Not located
—	—	—	—	—	—	Not located
—	—	55	—	0.88	—	Not located
—	—	—	—	—	—	Not located
—	—	51	176	1.50	—	Not equipped Not located
Tindall Limestone or Lower Unit Montejinni Limestone	—	46	—	1.13	—	
—	37	6	—	0.63	—	Not located
	55					
	64					
—	18	11	—	1.50	—	Not located
	58					
	65					
—	—	52	—	1.25	—	Not located
	—	—	—	—	—	Not located
Tindall Limestone	—	9	—	1.88	—	
Tindall Limestone	—	18	—	—	—	Not located
—	46	44	—	1.50	—	Not located
Tindall Limestone	46	44	—	2.25	—	Not located
—	—	—	—	—	—	Not located
—	—	—	—	—	—	Not located
—	—	57	59	1.25	—	Not located
Tindall Limestone	—	27	33	1.88	1322	See R.N. 3395
Tindall Limestone	—	54	59	4.50	1427	
Tindall Limestone	—	32	39	1.88	—	
Tindall Limestone	49	45	52	1.88	696	
—	—	54	60	1.20	—	
Tindall Limestone	61	32	—	1.00	—	Abandoned
Tindall Limestone or Antrim Plateau Volcanics	61	43	49	0.88	382	
Lower Unit Montejinni Limestone	56	48	61	2.00	690	
Antrim Plateau Volcanics	113	—	—	—	—	
Unconformity Mullaman Beds/	20	14	61	0.88	295	
Antrim Plateau Volcanics	136	—	—	—	—	

Reg. No.	Station No. or name	Position	Elevation (m)	Total depth (m)
LARRIMAH (continued)				
906	Dry River S/R No. 7	Old Birrimba homestead	215	63
1456	Army Bore No. 475	1.6 km north of Elsey Creek	158	31
1458	Army Bore No. 523	183 m west of 328-mile Peg	183	69
1459	Army Bore No. 525	46 m south railway track, Larrimah	194	61
1460	Army Bore No. 524	91 m south railway track, Larrimah	194	61
1461	Army Bore No. 526	183 m west railway track, Larrimah	194	—
1462	Army Bore No. 530	46 m west of road, Larrimah	194	45
2186	Larrimah Bore	Larrimah	194	—
2325	Elsey One Pull Bore	—	—	30
2326	Elsey No. 1	—	—	30
2379	Elsey Drum Bore	—	—	30
3395	Birdum S/R No. 1	21 km north-northwest of Larrimah	166	40
3545	Elsey No. 5—Giles Bore	—	—	75
5149	Mataranka 39/65	10 km south-southeast of Mataranka township	140	36
5492	House bore	Maryfield homestead	185	58
NEWCASTLE WATERS 1:250 000 SHEET AREA				
12	House bore	Newcastle Waters homestead	209	62
218	Newcastle Waters (Lake Woods) No. 1	Northwest edge Lake Woods	196	52
515	8A Causeway	13 km north-northeast Newcastle Waters homestead	221	100
591	Murranji S/R No. 9 (old)	37 km north-northwest of Newcastle Waters	226	81
592	Murranji S/R No. 9	37 km north-northwest of Newcastle Waters	226	81
907	Hickety Bore	21 km north-northwest of Newcastle Waters	216	73
1463	Army Bore No. 687	Nelly Waterhole 744-km Peg	210?	84
1530	Newcastle Waters No. 3	Approx. 19 km northwest of homestead	221	67
1896	Town Supply Bore	Newcastle Waters	209	57
1899	Town Supply Bore	Newcastle Waters	209	100
2350	Newcastle Waters Windy Point	52 km southeast of Newcastle Waters	205	60
3950	Hotel Bore	Newcastle Waters	209	—
4579	Newcastle Waters (New) Hickety	23 km northwest of Newcastle Waters	218	71
5685	Newcastle Waters—Burge	68 km south by west of homestead	202	93
5686	Benaud, Newcastle Waters	62 km south by west of homestead	200	53
5687	Hassett, Newcastle Waters	50 km south by west of homestead	201	62
5688	Bradman, Newcastle Waters	18 km south by west of homestead	204	52
5689	Grimmett, Newcastle Waters	27 km south of homestead	201	70
5690	McKay, Newcastle Waters	36 km south by west of homestead	198	65
5793	Sturt Plain	Sturt Plain homestead	221	76
TANUMBIRINI 1:250 000 SHEET AREA				
5761*	CCB, Borroloola Road	26 km east of Stuart Highway	241	97
5764	CCC, Borroloola Road	40 km east of Stuart Highway	227	115
5773*	CCE, Borroloola Road	72 km east of Stuart Highway	271	145
5782*	CCH, Borroloola Road	121 km east of Stuart Highway	283	92
5783	CCI, Borroloola Road	137 km east of Stuart Highway	280	134
5844	CCD, Borroloola Road	56 km east of Stuart Highway	258	124
5845*	CCF, Borroloola Road	89 km east of Stuart Highway	308	147
5846	CCG, Borroloola Road	105 km east of Stuart Highway	293	99
5864	CCJ, Borroloola Road	153 km east of Stuart Highway	274	91
2876	Nutwood Downs N.A.	Headwaters of Hodgson River	198	52
2877	Nutwood Downs N.B.	Headwaters Red Ochre Creek	198	78
879	Nutwood Downs No. 9	Headwaters of Brumby Creek	192	55
880*	Nutwood Downs No. 10	Near 8-mile Creek	189	34
2265	Dunmarra No. 2	16 km east of Dunmarra roadhouse	226	93
TENNANT CREEK 1:250 000 SHEET AREA				
505	South Barkly S/R No. 10	45 km east-southeast Brunchilly homestead	227	90
1200	Brunchilly No. 16	42 km east-southeast of homestead	227	69
1201	Brunchilly No. 14	39 km southeast of homestead	230	67
1208	Brunchilly No. 11	—	—	—
1209	Brunchilly No. 13	24 km southeast of homestead	230	66

* See notes on replacement bores on page 19 this Appendix.

Aquifer	Depth of Aquifers (m)	Depth standing water level (m)	Pump depth (m)	Supply l/s	Quality (ppm)	Remarks
—	55	37	—	0.63	335	
Tindall Limestone	—	—	—	5.00	—	Not located
Tindall Limestone	—	—	—	0.98	—	Not located
Tindall Limestone	—	—	—	—	—	Not located
Tindall Limestone	—	—	—	2.00	—	Not located
Tindall Limestone	—	—	—	—	—	Not located
Tindall Limestone	—	—	—	—	—	Not located
Tindall Limestone	—	—	—	—	1124	Not located
—	—	21	—	—	—	
—	—	23	—	—	—	
—	—	21	—	—	—	
Tindall Limestone	29	29	—	2.25	—	See R.N. 550
—	24	18	—	0.25	—	
Tindall Limestone	55	18	—	1.25	—	
	17	16	—	6.25	1039	
Tindall Limestone	54-55	51	—	2.25	1312	
Unconformity? between Merrina	52	50	—	1.31	—	
Beds and Tomkinson Beds						
Mullaman Beds or Merrina Beds	37	37	—	—	657	
Mullaman Beds or Tindall Limestone	64					
	85	62	71	1.75	1063	
	—	68	76	1.13	2860	See R.N. 592
Mullaman Beds?	—	70	—	2.25	1787	See R.N. 591
Mullaman Beds?	61	61	68	2.25	1309	
Mullaman Beds?	—	73	107	—	—	Probably near causeway over Newcastle Creek
	—	—	—	1.62	—	
Tomkinson Creek Beds?	52	—	—	0.75	811	
Tomkinson Creek Beds	54	53	98	0.81	768	
	99	53	—	—	—	
Mullaman Beds or Merrina Beds	—	—	—	2.38	452	
—	—	—	—	—	—	Not equipped
Mullaman Beds	—	63	65	2.25	1281	
Unconformity? Merrina Beds/	18	40	—	0.75	—	
Antrim Plateau Volcanics	37					
	48?					
Merrina Beds?	42	38	—	1.88	695	
	50					
Merrina Beds	40	40	—	1.88	575	
	61					
Merrina Beds	45-52	—	49	2.25	553	
Merrina Beds	40	40	—	2.25	647	
	65	—	—	—	—	
Merrina Beds	—	43	—	1.88	475	
Mullaman Beds?	—	—	—	—	872	
Unconformity Mullaman Beds? and	90	87	—	2.50	Good	
Middle Cambrian						
Middle Cambrian	76	76	—	2.50	Good	
Mullaman Beds	—	—	—	—	—	Dry hole
Mullaman Beds	—	—	—	—	—	Dry hole
Middle Cambrian	122	122	—	Unknown	Good	
Mullaman Beds	113	111	—	1.75	Good	
Middle Cambrian	—	—	—	—	—	Dry hole
Mullaman Beds	—	—	—	—	—	Dry hole
Mullaman Beds and Adelaidean	—	—	—	—	—	Dry hole
Upper Proterozoic or Mullaman Beds	—	—	—	1.19	—	
Tindall Limestone?	—	—	—	0.26	—	
Tindall Limestone?	—	—	—	2.50	—	
Nutwood Downs Volcanics	—	—	—	—	—	Dry hole
—	—	—	—	1.50	—	
Gum Ridge Formation or Anthony	50	50	—	2.50	3307	
Lagoon Beds	86					
Anthony Lagoon Beds	65	—	—	1.50	2531	Originally No. 3
Anthony Lagoon Beds	62	—	—	1.50	1230	Originally No. 4
Anthony Lagoon Beds or	—	—	—	1.75	1057	May be same bore as South
Gum Ridge Formation						Barkly S/R No. 11
Anthony Lagoon Beds	—	50	46	1.75	—	Abandoned—
						See R.N. 4189

Reg. No.	Station No. or name	Position	Elevation (m)	Total depth (m)
TENNANT CREEK (continued)				
3708	South Barkly S/R No. 12	27 km south-southwest of Brunchilly homestead	259	99
3859	South Barkly S/R No. 12	27 km south-southwest of Brunchilly homestead	259	57
4189	Brunchilly No. 13	24 km southeast of homestead	230	66
4521	Brunchilly No. 12	26 km southeast of homestead	227	70
	Barkly Highway 5A	389 km west of Camooweal	251	136
	Barkly Highway 12A	414 km west of Camooweal	262	60
	Barkly Highway 10A	457 km west of Camooweal	323	60
VICTORIA RIVER DOWNS 1:250 000 SHEET AREA				
157	Auvergne S/R Shoeing Tool Bore	10 km southeast of Moolooloo homestead	160	25
332	Auvergne S/R Shoeing Tool Bore	10 km southeast of Moolooloo homestead	160	34
511	Auvergne S/R Shoeing Tool Bore	10 km southeast of Moolooloo homestead	160	48
512	Wave Hill S/R No. 50 (Cullenjacky)	16 km southwest of Montejinni homestead	198	52
584	Wave Hill S/R No. 49 (King Bore)	8 km south of Townsend Creek	157	50
593	Murranji S/R Top Springs Depot No. 1	—	c. 195	16
594	Montejinni Station McCraes Bore	6 km south-southeast of homestead	189	43
595	Montejinni No. 2 (McGaskills)	18 km east-northeast of homestead	207	27
622	Murranji S/R—Top Springs Depot No. 1	—	—	16
901	Auvergne S/R (Companion)	Companion Creek	—	48
1088	V.R.D. 3 (Waterbag)	—	—	30
1090	Killarney No. 5	23 km north-northeast of New Killarney homestead	210	66
1091	Killarney No. 6	New Killarney homestead	184	53
1340	House Bore	Montejinni homestead	174	24
1501	Top Springs (Well)	—	—	—
1913	Police Station	Top Springs	176	19
1988	Dry River S/R No. 9 (Charlies Hole)	18 km northeast of New Top Springs town site	194	34
2035	Top Springs Reserve	11 km southeast of New Top Springs town site	197	37
2376	Killarney New Well	—	—	10
2415	Camfield (Farquarson)	11 km southwest of Karibaldi Yard	155	23
3557	Killarney (Horse Creek)	9 km north-northeast of homestead	c.189	10
3558	Killarney—Pikers Retreat	23 km south-southeast of homestead	224	38
3564	Killarney—Callighers	—	—	98
3565	Killarney—Bullock Hole	Near Battle Creek	—	6
3747	Killarney—Bauhinia	29 km north-northeast of homestead	215	18
3767	Killarney Dowsett No. 1	5 km southwest of homestead	—	181
3768	Killarney Dowsett No. 2	2 km east of homestead	—	76
4049	Camfield Site No. 3 (Doleso)	3 km south-southeast of No. 49 Wave Hill S/R (R.N. 584)	162	107
4628	Camfield Rara	19 km south by east Pigeon Hole homestead	139	84
4666	Killarney—Bull Creek	8 km west by north of homestead	—	52
4762	Montejinni—Isadore	42 km west-southwest of homestead	—	18
4763	Montejinni—McCallum	6 km west of Karibaldi Yards	137	16
4764	Montejinni—Winari	21 km south-southwest of homestead	169	11
4765	Montejinni—Ogdens	26 km west of homestead on Armstrong River	—	15
4769	Camfield—Bull paddock (stud bore)	19 km southeast of Pigeon Hole homestead	158	16
4773	Killarney	16 km east-southeast of Killarney homestead	226	37
4807	Killarney (Monster)	18 km east by south of homestead	226	46
5208	Montejinni Station	—	—	30
5396	Montejinni, Armstrong Bore	6 km at 340° from homestead	162?	192
5423	Stock Inspector's Residence, Top Springs	—	175	30
5424	Killarney—Companion Water Hole Bore	Companion Creek Crossing	175	14
5426	Killarney—Companion Well	Companion Creek Crossing	162	12
5444	Town bore	New Top Springs town site	198	54
5461	Killarney, Comet Creek	24 km northwest of homestead—Comet Creek, near Battle Creek	—	106

Aquifer	Depth of Aquifers (m)	Depth standing water level (m)	Pump depth (m)	Supply l/s	Quality (ppm)	Remarks
Anthony Lagoon Beds or	85	82	—	—	1017	Not equipped
Gum Ridge Formation	94			1.25		
—	—	—	—	—	—	Dry hole 1st attempt at R.N. 3708
Gum Ridge Formation?	56	54	50	1.88	1100	
	59					
Anthony Lagoon Beds	—	—	—	1.50	1064	
Gum Ridge Formation	—	70	—	2.00	—	Abandoned
Gum Ridge Formation	—	43	—	0.13	420	Abandoned
Gum Ridge Formation	—	37	—	0.03	—	Abandoned
—	—	—	—	—	—	Abandoned 2nd attempt A.I.B.
—	—	—	—	—	—	Abandoned 3rd attempt
Antrim Plateau Volcanics	—	25	—	—	—	See R.N. 5479
Unconformity? Montejinni Limestone/Antrim Plateau Volcanics	—	26	—	3.00	368	
Antrim Plateau Volcanics	6	—	33	1.13	400	
	48	21				
—	6	6	—	1.50	—	Not located
	15					
Antrim Plateau Volcanics?	—	20	—	1.00	473	
Montejinni Limestone	—	19	—	2.25	392	
—	6	6	—	1.50	—	1st attempt abandoned (not located)
	15					
—	—	—	—	—	—	Dry (see R.N's 5424, 5426)
—	—	—	—	—	—	
Antrim Plateau Volcanics	—	10	—	—	—	Originally V.R.D. No. 5
Antrim Plateau Volcanics	—	—	—	—	308	Originally V.R.D. No. 6
—	—	—	—	—	493	
—	—	—	—	—	—	Not located
Montejinni Limestone	12	10	17	1.13	663	1st attempt
Unconformity Montejinni Limestone/ Antrim Plateau Volcanics	14					
Montejinni Limestone	11	11	—	3.00	441	
	22					
—	—	—	—	—	Good	A.I.B. Quarantine Reserve
—	—	—	—	—	—	
Antrim Plateau Volcanics	—	12	—	—	—	
Antrim Plateau Volcanics	9	9	—	0.38	—	
Antrim Plateau Volcanics	26	24	—	1.75	445	
	38	24	—			
—	42	4	—	—	—	Not located
	79					
—	—	—	—	—	—	
Montejinni Limestone	9	6	—	3.00	444	
Antrim Plateau Volcanics	12	—	—	0.19	—	
Antrim Plateau Volcanics	64	—	—	2.00	217	Supply dropped at end of dry season
Antrim Plateau Volcanics	24	21	—	1.38	367	
	98		—	—		
	104		—			
Antrim Plateau Volcanics	73	—	—	2.56	456	
Antrim Plateau Volcanics	28	9	—	0.06	—	
	45	—	—	1.50	—	
Antrim Plateau Volcanics	—	—	—	2.25	479	
Antrim Plateau Volcanics	—	—	—	2.25	357	
Antrim Plateau Volcanics	—	—	—	2.50	451	
Antrim Plateau Volcanics	—	—	—	2.50	430	
Antrim Plateau Volcanics	—	—	—	—	502	
Unconformity, Montejinni Limestone/ Antrim Plateau Volcanics	17	17	—	2.50	—	1st attempt see R.N. 4807
Unconformity between Montejinni Limestone and Antrim Plateau Volcanics	31	19	—	0.18	—	2nd attempt
	45	—	—	0.23-0.25	—	
—	—	—	—	2.50	—	Not located
Antrim Plateau Volcanics	11	11	—	0.08	570	
	180	9	—	1.00	—	
Antrim Plateau Volcanics	13	13	—	0.06	484	
	19	9	—	0.60	—	
	27	8	—	0.81	—	
Antrim Plateau Volcanics	5	3	—	0.15	—	1st attempt see R.N. 901
Antrim Plateau Volcanics	4	3	—	1.80	—	2nd attempt see R.N. 901
Antrim Plateau Volcanics	52	35	—	1.38	515	
	53					
	53-54					
Antrim Plateau Volcanics	23	7	—	0.20	—	
	89-91	—	—	1.50	—	
	101	—	—	1.80	—	

Reg. No.	Station No. or name	Position	Elevation (m)	Total depth (m)
VICTORIA RIVER (continued)				
5462	New house bore	Killarney homestead	180	30
5478	VRD Waterbag Replacement	Waterbag Creek Crossing—9 m from existing bore	—	53
5479	VRD Shoeing Tool Replacement	10 km southeast of Moolooloo homestead	154	180
	Killarney homestead	New Killarney homestead	184	—
5578	—	39 km northeast of new Top Springs town site on Willeroo Beef Road	244	80
WAVE HILL 1:250 000 SHEET AREA				
510	Wave Hill, Police Bore	Police Station	168	214
583	Wave Hill S/R No. 47 (Wyalong)	16 km south of Camfield homestead	148	—
585	Wave Hill S/R No. 48 (Red Rock)	8 km east by south Camfield homestead	132	100
703	Camfield No. 2	—	—	15
704	Camfield No. 2	—	—	22
813	Wave Hill No. 1	21 km northeast of homestead	192	22
814	Wave Hill No. 2	Toby Creek—39 km east-northeast of homestead	169	67
815	Wave Hill No. 3	Camfield Creek—29 km east by south of homestead	184	32
816	Wave Hill No. 3A	Camfield Creek—29 km east by south of homestead	184	34
817	Wave Hill No. 4	21 km southeast of homestead	198	19
818	Wave Hill No. 5	Wave Hill homestead	201	19
819	Wave Hill No. 5A	Wave Hill homestead	201	67
820	Wave Hill No. 5B	Wave Hill homestead	201	14
821	Wave Hill No. 6	Gordy Creek—13 km southwest of homestead	202	60
822	Wave Hill No. 7	Camfield Creek—13 km south of homestead	216	25
823	Wave Hill No. 8	Fergusson Creek—26 km southeast of homestead	—	30
824	Wave Hill No. 9	Gordy Creek—40 km south-southwest of homestead	c. 274	183
825	Wave Hill No. 10	Camfield River—32 km southeast of homestead	c. 187	—
826	Wave Hill No. 11	5 km southeast of No. 22	168	22
827	Wave Hill No. 11A	Beside No. 11	—	—
828	Wave Hill No. 12	Croker Creek—8 km northeast of homestead	189	22
829	Wave Hill No. 13	8 km Creek—6 km north by west of homestead	c. 192	—
830	Wave Hill No. 14	18 km north-northeast of homestead	181	88
831	Wave Hill No. 15	Camfield River—11 km southeast of homestead	207	28
832	Wave Hill No. 16	1.6 km northeast of No. 17	c. 204	26
833	Wave Hill No. 17	Camfield Creek—10 km southeast of homestead	206	47
836	Wave Hill No. 20	1.6 km south by west of bore WP (R.N. 2341)	—	60
837	Wave Hill No. 21	Near confluence Fergusson Creek, Camfield River	—	91
838	Wave Hill No. 22	Camfield River—31 km north-northwest of Cattle Creek homestead	158	140
839	Wave Hill No. 23	Fergusson Creek—3 km southwest of Bore WP	—	77
840	Wave Hill No. 24	6 km west of homestead	—	227
841	Wave Hill No. 25	18 km east of homestead	200	38
842	Wave Hill No. 26	8 km southeast of No. 2	—	—
843	Wave Hill No. 27	29 km southeast of homestead	—	18-21
844	Wave Hill No. 28	Near Mindie Well	—	10
845	Wave Hill No. 29	Near confluence Camfield River, Fergusson Creek	299	23
846	Wave Hill No. 30	Wave Hill homestead	—	18
847	Wave Hill No. 31	Wave Hill homestead	—	18
848	Wave Hill No. 32	Wave Hill homestead	201	20
849	Wave Hill No. 33 (WK)	2 km south of homestead	207?	12
850	Wave Hill No. 34 (WA)	13 km south-southeast of No. 22	c. 183	45
851	Wave Hill No. 35 (WC)	10 km northwest of Cattle Creek homestead	197	61
852	Wave Hill No. 36 (WF)	18 km southwest of Cattle Creek homestead	195	61
853	Wave Hill No. 37 (WE)	14 km south by west of Cattle Creek homestead	195	66
854	Wave Hill No. 38 (WG)	27 km west of Cattle Creek homestead	198	39
855	Wave Hill No. 39 (WL)	Barry Creek—39 km south-southeast of homestead	—	16
856	Wave Hill No. 40 (WB)	18 km north-northeast of Cattle Creek homestead	198	115

Aquifer	Depth of Aquifers (m)	Depth standing water level (m)	Pump depth (m)	Supply l/s	Quality (ppm)	Remarks
Antrim Plateau Volcanics	10	7	—	3.00	—	
	19					
—	15	9	—	—	—	
	40	11	—	—	—	
Antrim Plateau Volcanics	69	15	—	0.06	—	
	78	14	—	0.50	—	
	142	12	—	1.00	—	
Antrim Plateau Volcanics	34	34	—	—	—	Replacement for
	82					VRD No. 6
Montejinni Limestone	53	52	—	0.63	—	
Victoria River Group	24	2	87	0.88	750	
	201			—		
	214			0.75		
Antrim Plateau Volcanics	9	8	24	3.75	500	
	35					
Antrim Plateau Volcanics	10	9	24	3.75	543	
	71					
	76					
	98					
—	—	11	—	0.06	—	Not located. 1st attempt
						abandoned
—	22	9	—	0.25	—	Not located 2nd attempt
Antrim Plateau Volcanics	—	11	21	1.50	566	
Antrim Plateau Volcanics	—	9	21	1.50	400	
Antrim Plateau Volcanics	—	9	27	0.52	700	See R.N. 816
Antrim Plateau Volcanics	—	—	—	0.52	—	See R.N. 815
Antrim Plateau Volcanics	—	9	14	0.50	523	Originally 1.25 l/s
Antrim Plateau Volcanics	—	9	18	0.38	360	See R.N. 819, 820
Antrim Plateau Volcanics	—	8	—	0.38	—	See R.N. 818, 820
Antrim Plateau Volcanics	—	—	—	1.13	—	See R.N. 818, 819
Antrim Plateau Volcanics	—	9	21	0.38	847	—
Antrim Plateau Volcanics	—	6	—	1.25-1.50	—	
Antrim Plateau Volcanics	—	—	—	—	—	Dry
—	—	—	—	—	—	Abandoned
—	—	—	—	—	—	No information—dry
Antrim Plateau Volcanics	—	7	—	—	—	Replaced by No. 22
—	—	—	—	—	—	
Antrim Plateau Volcanics	—	11	21	0.90	—	See R.N. 5450
—	—	—	—	—	—	No information, dry bore
Victoria River Group?	88	12	34	2.25	—	
Antrim Plateau Volcanics	—	6	—	0.38	—	Abandoned
Antrim Plateau Volcanics	—	6	—	0.75	—	Abandoned
Antrim Plateau Volcanics	—	9	30	0.94	—	
—	—	—	—	—	—	Dry bore
—	—	—	—	—	—	Abandoned
Antrim Plateau Volcanics	—	—	—	1.88	651	
—	—	—	—	—	—	Dry bore
—	—	—	—	—	—	Dry bore
Antrim Plateau Volcanics	—	—	—	—	499	—
—	—	—	—	—	—	Dry bore
—	—	—	—	—	—	Dry bore
—	—	—	—	—	—	Dry bore
Antrim Plateau Volcanics	—	5	22	2.00	—	—
Antrim Plateau Volcanics	—	—	—	—	—	Dry bore
Antrim Plateau Volcanics	—	—	—	—	—	Dry bore
Antrim Plateau Volcanics	—	—	—	0.05-0.20	—	
Antrim Plateau Volcanics	11	4	—	0.33-1.00	—	
Antrim Plateau Volcanics	34	—	—	0.38	—	Abandoned
Antrim Plateau Volcanics	58	37	—	1.56	595	
Unconformity Montejinni Limestone/ Antrim Plateau Volcanics	53	32	—	2.00	1654	
Unconformity Montejinni Limestone/ Antrim Plateau Volcanics	66	34	—	—	1016	
Antrim Plateau Volcanics	35	11	—	1.38	—	
—	—	—	—	—	—	Abandoned. See R.N. 2340
—	41	—	—	1.38	—	Abandoned

Reg. No.	Station No. or name	Position	Elevation (m)	Total depth (m)
WAVE HILL (continued)				
882	Post Office Bore	Wave Hill homestead	201	25
883	Post Office No. 2	Wave Hill homestead	201	21
1016	Camfield No. 1	—	—	20
1034	Camfield No. 1	—	—	—
1085	Camfield No. 2	—	—	14
1096	Victoria River Downs No. 11	Black Gin Creek	—	47
1099	Victoria River Downs	Poison Creek	—	—
1704	Camfield No. 3	—	—	—
2336	Wave Hill No. 41 (WQ)	Cattle Creek—60 km north-northwest of Cattle Creek homestead	c. 174	274
2337	Wave Hill No. 42 (WD)	Cattle Creek homestead	187	28
2338	Wave Hill No. 43 (WT)	27 km southwest of Cattle Creek homestead	192	42
2339	Wave Hill No. 44 (WS)	6 km southwest of homestead	—	274
2340	Wave Hill No. 45 (WL)	Barry Creek—39 km south-southeast of homestead	235	35
2341	Wave Hill No. 47 (WP)	Fergusson Creek—23 km south-southeast of homestead	219	91
2414	Camfield—Chungari	Chungari Creek—29 km south of homestead	171	48
2836	Wave Hill (WR)	Camfield Creek—near No. 3	c. 183	93
4048	Camfield No. 2 (Horse Creek)	23 km southeast of homestead	146	40
4303	House Bore	Camfield homestead	120	76
4407	Camfield—Sailor Jack	27 km south-southeast of homestead	139	72
4530	Camfield—Barry Knob	18 km southwest of homestead	183	55
4531	Camfield—Ram Creek	10 km southwest of homestead	163	61
4766	Camfield—Rennie Creek	27 km south-southwest of homestead	169	183
4767	Camfield—Lignum	Camfield River 26 km southeast of homestead	137	12
4768	Camfield—Sheep Yard	8 km southeast of homestead	—	13
4780	Wave Hill—new homestead site No. 6	3 km east of Police Station	—	349
5429	Wave Hill—new homestead site No. 6	—	—	30
5450	Wave Hill—No. 2 site for No. 12 bore	11 km northeast of homestead	—	152
5456	Wave Hill—new homestead site No. 6	—	—	30
5489	Wave Hill school bore	Near Welfare settlement	—	215
WINNECKE CREEK 1:250 000 SHEET				
	Hooker Creek No. 5	Homestead	320	52
	Hooker Creek 19-mile	27 km north of homestead	346	54
	Hooker Creek No. 1	Homestead	320	50
	Hooker Creek No. 6	Homestead	320	55
	Hooker Creek No. 7	Homestead	320	61
	Hooker Creek No. 8	Homestead	320	101
	Hooker Creek No. 9	Homestead	320	45
TANUMBIRI				
5942	15 mile Cape Crawford Road	—	—	104
5954	48 mile Cape Crawford Road	—	—	151
6066	55 mile Cape Crawford Road	—	—	168
6067	75 mile Cape Crawford Road	—	—	139

Aquifer	Depth of Aquifers (m)	Depth standing water level (m)	Pump depth (m)	Supply l/s	Quality (ppm)	Remarks
Antrim Plateau Volcanics	—	—	—	small	—	
Antrim Plateau Volcanics	—	—	—	—	—	
—	—	—	—	—	—	Not located. Dry hole
—	—	—	—	—	—	Not located. 2nd attempt dry
—	9	9	—	0.06	—	Not located. 3rd attempt abandoned
Victoria River Group	—	—	—	—	399	
Victoria River Group	—	—	—	—	563	
—	—	—	—	—	—	Not located
Antrim Plateau Volcanics	9	—	—	0.13	—	Abandoned due to salt
Victoria River Group?	100	—	—	0.50	—	
	?	—	—	4.50	—	
Montejinni Limestone?	25	—	—	3.75	811	
Montejinni Limestone or Antrim Plateau Volcanics	25	—	—	—	569	
	36-37	—	—	—		
—	—	—	—	—	—	Dry bore
Antrim Plateau Volcanics	31	—	—	2.50	—	See R.N. 855
Antrim Plateau Volcanics	—	—	—	0.52	—	
Antrim Plateau Volcanics	24	6	—	2.25	282	
	37	6	—	3.63	—	
	39	7	—	3.60	—	
—	—	—	285	2.06	676	
—	14	9	98	2.25	492	
	35					
Antrim Plateau Volcanics	24	9	—	1.56	451	
	47					
	69					
Antrim Plateau Volcanics	9	7	—	1.75	4594	
	14					
	64					
Antrim Plateau Volcanics	24	13	—	3.60	631	
Antrim Plateau Volcanics	33	16	—	1.50	436	
—	—	—	—	—	—	
Antrim Plateau Volcanics	—	—	—	2.25	2399	
Antrim Plateau Volcanics	—	9	—	—	Salty	Abandoned
Victoria River Group	315	55	—	—	—	Salty abandoned
Victoria River Group	12	12	—	2.25	—	
Antrim Plateau Volcanics	22	—	—	—	—	See R.N. 828
Antrim Plateau Volcanics	13	—	—	—	—	Abandoned
Victoria River Group	18	12	—	0.01	Good	
	37	12	—	0.03		
	207-215	2	—	1.50		
Antrim Plateau Volcanics?	—	26	—	1.25	647	Polluted
Antrim Plateau Volcanics?	—	26	—	2.38	—	
Antrim Plateau Volcanics?	38	—	—	—	—	Supply failing. Not in use
	50	—	—	1.50	495	
Antrim Plateau Volcanics?	—	—	—	0.63	470	
Antrim Plateau Volcanics?	42	—	—	0.15	820	Observation bore
Antrim Plateau Volcanics?	32	—	—	—	—	
Antrim Plateau Volcanics?	37	—	—	—	—	
Victoria River Group	97	—	—	2.50	472	
Antrim Plateau Volcanics	28	—	—	1.00	—	Pump tested at 1200 gph
	40	—	—	1.25	424	
Tindall Limestone or Anthony Lagoon Beds	88	87	—	1.75	568	Replacement for R.N. 5761
As above	142	140	—	—	635	Replacement for R.N. 5773
As above	155	155	—	1.88	—	Replacement for R.N. 5845
As above	128	128	—	1.88	—	Replacement for R.N. 5782

APPENDIX 2. CHEMICAL ANALYSES OF BORE WATER

Analyses in parts per million. x = not detected. x0.02 = not detected, detection limit 0.02 ppm. — = not determined.
Specific conductivity (S.C.) in microho/cm. * Detailed analysis rejected owing to gross imbalance.

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	Year	Laboratory
BEETALOO 1:250 000 SHEET AREA																					
316	108.2	53.4	184	25	238.9	194.5	444.4	x	1.0	39.6	12.5	—	x0.02	0.017	0.5	0.12	1692	7.66	990	1966	A.M.D.L.
517	101.0	56.1	123	23	187.2	107.0	475.2	x	0.7	45.3	8.7	—	x0.02	0.032	0.4	0.03	1293	7.6	872	1966	A.M.D.L.
519	98.5	46.8	180	23	222.2	270.0	391.9	x	0.9	15.3	4.8	—	x0.02	0.01	0.3	0.11	1706	7.6	1052	1966	A.M.D.L.
522	71.7	45.6	238	13	272.2	281.1	327.1	x	1.3	27.8	0.6	—	0.02	0.018	0.4	0.07	1854	7.95	1128	1966	A.M.D.L.
541	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	670	—	A.I.B.
1056	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2033	—	A.I.B.
1186	105.8	69.4	78	11	141.4	132.9	476.8	x	0.5	32.1	3.2	—	x0.02	0.019	0.2	0.07	1288	7.00	816	1965	A.M.D.L.
1187	94.7	67.2	118	12	199.6	228.6	376.5	x	0.6	34.9	4.7	—	0.05	0.047	0.3	0.04	1553	7.60	975	1966	A.M.D.L.
1233	60.3	41.6	119	11	182.8	95.1	290.1	x	0.6	26.5	9.8	—	x0.02	0.003	0.3	0.03	1150	7.00	669	1965	A.M.D.L.
1290	110.7	50.1	316	28	347.3	427.1	404.3	x	2.2	23.7	4.0	—	x0.02	0.049	0.9	0.08	2435	7.55	1546	1966	A.M.D.L.
1297	119.9	62.2	243	11	390.1	396.7	216.0	x	0.6	36.1	8.2	—	0.02	0.062	0.4	0.01	2216	7.80	1418	1966	A.M.D.L.
1529	72.1	46.1	102	11	176.1	113.6	305.5	x	1.4	26.5	4.7	—	x0.02	—	0.3	0.06	1208	7.85	572	1966	A.M.D.L.
1533	72.5	57.5	148	22	274.0	167.5	266.1	x	0.8	14.3	15.5	—	x0.02	0.14	0.7	0.06	1503	6.80	910	1965	A.M.D.L.
1622	111.2	60.5	214	15	297.2	344.0	287.0	x	0.9	29.3	1.9	—	x0.02	0.029	0.5	0.06	1947	7.90	1245	1966	A.M.D.L.
1623	109.1	71.9	52	13	119.2	223.9	339.5	x	3.0	17.2	—	—	0.02	0.03	0.2	0.19	1219	7.95	789	1966	A.M.D.L.
1888	101.1	53.2	130	16	223.7	228.8	280.0	x	0.9	17.2	0.1	—	0.04	0.019	0.4	0.04	1443	7.10	930	1965	A.M.D.L.
2165	50	61	365	40	230	257	756	x	3.7	—	7.0	—	—	—	—	—	—	—	1769	—	A.I.B.
2348	94.7	55.4	144	24	217.2	149.5	450.6	x	0.9	39.0	10.0	—	x0.02	—	0.9	x0.01	1517	7.70	890	1966	A.M.D.L.
2351	109.8	57.4	148	24	218.2	148.5	493.8	x	1.0	40.3	11.2	—	x0.02	0.022	0.5	0.12	1555	7.50	880	1966	A.M.D.L.
2352	182.9	72.4	52	12	48.0	599.6	246.9	x	1.8	23.0	0.9	—	x0.02	—	0.3	0.24	1509	7.65	1130	1966	A.M.D.L.
2353	109.0	57.4	126	24	200.5	115.0	499.0	x	0.7	44.8	11.5	—	x0.02	—	0.4	x0.01	1490	7.50	486	1966	A.M.D.L.
2381	129.1	71.0	297	23	367.6	419.3	410.4	x	1.5	24.3	1.1	—	x0.02	0.006	0.6	0.08	2298	7.10	1554	1965	A.M.D.L.
3454	47.0	21.0	12	24	11.0	6.0	292.0	x	0.7	58.0	x0.1	0.03	x0.02	0.02	0.2	x0.01	473	7.40	310	1966	A.M.D.L.
4695	71.2	43.8	109	11	136.6	147.7	329.9	x	2.4	23.6	2.8	—	x0.02	0.013	0.5	0.06	1127	7.30	711	1965	A.M.D.L.
4912	103.5	56.1	112	21	195.6	105.3	493.8	x	0.6	45.1	10.2	—	x0.02	0.007	0.3	0.06	1372	7.55	808	1966	A.M.D.L.
4913	74.6	47.6	22	8	46.2	53.0	398.1	x	1.1	44.8	4.9	—	x0.02	—	0.1	0.25	751	7.70	403	1966	A.M.D.L.
4916	99.4	54.6	142	24	224.2	149.0	430.0	x	1.0	32.0	10:1	—	x0.02	—	0.5	x0.01	1593	7.55	475	1966	A.M.D.L.
5432	69.8	44.1	27	10	37.0	18.5	419.7	x	0.5	53.8	5.4	—	x0.02	0.032	0.1	0.01	679	81.0	453	1966	A.M.D.L.
5433	173.3	85.8	380	33	450.4	545.6	555.5	x	1.4	30.5	0.6	—	x0.02	0.015	0.9	0.08	2952	7.65	2021	1966	A.M.D.L.
5684	119.7	57.0	263	26	304.9	365.8	410.3	x	2.1	25.7	4.2	—	x0.02	0.021	0.9	0.09	2122	7.60	1392	1965	A.M.D.L.
DALY WATERS 1:250 000 SHEET AREA																					
53	110.0	67.0	235	42	310.0	206.0	588.0	—	—	—	3.5	—	—	—	—	—	—	—	1562	—	A.I.B.
* 552	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1187	—	A.I.B.
* 555	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1396	—	A.I.B.
555	115.0	64.0	235	36	326.0	216.0	573.0	—	0.6	—	6.0	—	—	—	—	—	—	—	1586	—	A.I.B.
555	136.0	61.0	230	32	297.0	196.0	599.0	x	0.5	43.0	8.2	0.02	x0.02	0.01	0.4	0.05	2103	6.95	1355	1966	A.M.D.L.
556	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1824	—	A.I.B.
* 557	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1427	—	A.I.B.
557	122.0	64.0	228	31	303.0	207.0	563.0	x	0.6	39.0	9.3	0.01	0.06	x0.01	0.4	0.06	2091	6.70	1337	1966	A.M.D.L.
* 586	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	645	—	A.I.B.
586	92.0	47.0	9	4	9.0	16.0	510.0	x	0.4	39.0	0.5	0.02	x0.02	0.11	0.1	0.06	792	7.20	454	1966	A.M.D.L.
* 587	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	689	—	A.I.B.
587	55.0	31.0	2	2.6	8.0	—	133.0	34	—	—	—	—	—	0.2	—	—	500	8.05	324	—	A.I.B.

DALY WATERS (continued)

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	Year	Laboratory
587	106.0	40.0	16	5	28.0	16.0	495.0	x	0.4	35.0	1.7	0.01	x0.02	0.03	0.1	0.08	826	7.25	485	1966	A.M.D.L.
588	19.0	55.0	20	8	35.0	12.0	337.0	7	0.2	—	1.0	—	—	—	—	—	—	—	494	—	A.I.B.
* 588	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	419	1965	W.R.B.
588	106.0	38.0	15	6	25.0	22.0	492.0	x	0.3	36.0	0.6	0.01	0.03	0.02	0.1	0.04	811	7.15	488	1966	A.M.D.L.
589	59.0	30.0	2	3	2.0	3.0	331.0	x	x0.1	24.0	x0.1	x0.01	x0.02	0.03	x0.1	x0.01	420	7.9	303	1966	A.M.D.L.
* 590	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2117	—	A.I.B.
908	8.0	68.0	17	5	15.0	—	432.0	—	0.52	—	1.0	—	—	—	—	—	—	—	546	—	A.I.B.
908	84.0	52.0	14	3	10.0	15.0	516.0	x	0.4	34.0	0.3	0.02	x0.02	0.02	0.1	0.05	790	7.15	456	1966	A.M.D.L.
1982	106.0	34.0	3	5	2.0	4.0	504.0	x	0.2	30.0	x0.1	0.02	0.02	0.03	0.2	x0.01	620	7.6	426	1966	A.M.D.L.
2264	94.0	52.0	127	50	136.0	74.0	602.0	x	1.2	50.0	5.8	0.01	0.02	0.06	0.4	0.02	1345	7.75	920	1966	A.M.D.L.
4518	80.0	38.0	13	7	5.0	23.0	441.0	x	0.8	49.0	x0.1	x0.01	x0.02	0.03	0.4	0.02	619	7.7	407	1966	A.M.D.L.
*5395	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1193	1966	W.R.B.
*5425	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1457	1966	W.R.B.
Daly Waters homestead	141.0	60.0	216	30	292.0	194.0	593.0	—	0.7	37.0	6.1	0.01	0.12	x0.01	0.4	0.05	2043	6.7	1338	1966	A.M.D.L.
Natural well	2.5	0.4	1.4	1.9	2.0	1.0	11.0	x	x0.1	17.0	1.7	0.02	x0.02	0.03	x0.1	x0.01	29	6.6	20	1966	A.M.D.L.

DELAMERE 1:250 000 SHEET AREA

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	Year	Laboratory
1346	50.0	24.0	60	7	8.0	9.0	414.0	x	0.6	28.0	0.3	x0.01	0.02	0.03	0.8	0.09	610	7.8	371	1966	A.M.D.L.
4488	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	492	—	—
4792	12.0	x1.0	112	1	9.0	12.0	298.0	x	0.2	44.0	x0.1	x0.01	x0.02	0.09	0.9	0.07	483	8.15	325	1966	A.M.D.L.
5402	25.0	40.0	98	2.1	13.0	—	234.0	8	0.1	—	—	—	—	0.2	—	—	530	7.85	476	1966	W.R.B.
5402	27.0	32.0	78	1	7.0	21.0	402.0	x	0.6	68.0	x0.1	x0.01	x0.02	0.03	1.1	0.04	618	7.8	397	1966	A.M.D.L.
5421	8.0	6.0	225	7.7	187.0	—	173.0	x	0.5	—	—	—	—	2.3	—	—	1020	7.5	616	—	W.R.B.
5459	16.0	22.0	185	—	45.0	—	143.0	—	—	—	0.3	—	—	—	—	—	225	7.56	218	1966	W.R.B.
5544	63.0	30.0	27	3	23.0	3.0	367.0	x	0.3	64.0	x0.1	0.02	0.03	0.01	0.5	0.07	624	7.3	391	1966	A.M.D.L.

HELEN SPRINGS 1:250 000 SHEET AREA

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	Year	Laboratory
104	123.5	66.1	151	26	272.1	146.5	504.5	x	0.7	42.7	13.5	—	x0.02	0.2	0.5	0.03	1678	7.3	1079	1965	A.M.D.L.
108	112.9	66.9	77	4	220.6	81.9	410.3	x	0.4	64.9	8.8	—	x0.02	0.015	0.2	0.03	1361	7.60	780	1965	A.M.D.L.
127	140.3	84.9	224	33	451.8	269.5	410.3	x	0.8	35.3	13.1	—	x0.02	0.05	0.5	0.05	2360	7.6	1460	1965	A.M.D.L.
134	147.9	78.6	182	31	352.7	199.2	518.4	x	0.9	35.3	15.8	—	0.03	x0.001	0.4	0.04	2075	6.90	1271	1965	A.M.D.L.
140	446.7	204.8	880	23	1697.7	1273.6	238.4	x	0.9	41.2	92.8	—	0.02	0.005	1.0	0.06	6558	7.25	4583	1965	A.M.D.L.
192	144.6	78.3	218	31	373.5	254.3	459.8	x	1.2	31.0	11.0	—	x0.02	0.02	0.3	x0.1	2146	7.20	1371	1965	A.M.D.L.
219	73.1	33.6	84	16	115.6	102.9	308.6	x	1.1	46.6	29.3	—	0.02	0.027	0.8	0.01	1063	7.55	656	1965	A.M.D.L.
237	144.1	65.6	545	30	636.4	640.3	352.0	x	2.2	49.0	53.4	—	x0.02	0.019	1.0	0.06	3435	7.30	2255	1965	A.M.D.L.
381	48.8	27.7	56	2	33.4	23.5	348.7	x	0.4	36.8	2.3	—	0.02	0.019	x0.1	x0.01	630	7.50	384	1965	A.M.D.L.
* 410	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2302	—	A.I.B.
418	57.0	35.7	63	11	36.4	28.8	432.1	x	0.4	60.1	1.7	—	x0.02	0.686	0.2	0.04	757	7.45	410	1965	A.M.D.L.
419	56.6	34.7	59	2	19.7	3.7	484.5	x	0.5	52.2	7.5	—	x0.02	0.021	0.1	x0.01	724	7.70	447	1965	A.M.D.L.
420	31.8	41.4	250	4	127.8	120.6	586.3	x	1.2	24.3	13.9	—	0.02	0.009	0.4	x0.01	1462	7.45	929	1965	A.M.D.L.
520	49.0	26.9	156	19	139.6	145.3	364.1	x	1.7	34.0	15.7	—	x0.02	0.027	0.3	0.03	1231	7.85	701	1965	A.M.D.L.
521	146.7	71.0	235	23	376.5	494.6	277.7	x	0.6	16.9	0.1	—	x0.02	0.012	0.3	0.09	2379	7.80	1498	1965	A.M.D.L.
702	202.7	215.7	395	61	1203.2	267.5	432.0	x	0.9	58.5	5.6	—	0.02	0.012	0.6	0.07	4290	7.15	2520	1965	A.M.D.L.
927	58.2	71.4	91	5	84.0	49.8	598.8	x	0.7	86.1	10.9	—	x0.02	0.01	0.2	0.01	1079	7.55	700	1965	A.M.D.L.
1193	134.1	71.8	150	29	279.2	132.1	567.8	x	0.5	40.5	12.8	—	0.03	x0.001	0.2	0.03	1747	7.40	1085	1965	A.M.D.L.
1194	72.1	49.8	53	2	74.7	29.6	472.2	x	0.5	81.7	7.7	—	x0.02	0.607	0.1	x0.01	886	7.65	481	1965	A.M.D.L.
1199	134.4	69.7	162	31	304.9	137.9	532.2	x	1.1	31.2	15.4	—	x0.02	—	0.4	0.05	1850	7.10	1110	1965	A.M.D.L.

Reg. No.	Ca	Mg	Na	K	Cl -	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	Year	Laboratory
HELEN SPRINGS (continued)																					
1202	270.0	129.0	500	34	849.3	789.7	370.3	x	1.4	31.9	10.2	—	0.02	0.027	0.7	0.13	4028	7.10	2801	1965	A.M.D.L.
1203	432.9	171.4	430	26	769.5	1460.4	243.8	x	2.4	22.7	14.1	—	0.03	x0.001	1.0	0.23	4426	7.10	3487	1965	A.M.D.L.
1205	110.7	60.5	720	27	616.1	852.6	379.6	x	2.7	36.6	32.6	—	0.02	0.019	1.3	0.08	3680	7.40	2590	1965	A.M.D.L.
1206	179.3	82.1	988	64	786.4	1429.6	391.9	x	2.1	35.7	41.3	—	0.02	0.007	2.8	0.08	5110	7.35	3596	1965	A.M.D.L.
1288	49.9	26.2	344	30	204.5	397.5	422.8	x	2.7	31.6	21.4	—	x0.02	0.02	0.8	x0.01	2074	7.80	1273	1965	A.M.D.L.
1289	129.5	62.4	450	17	514.1	625.1	280.8	x	2.2	18.9	17.9	—	0.02	0.015	0.9	0.11	3078	7.80	1978	1965	A.M.D.L.
1291	131.9	70.7	177	27	321.6	172.8	504.5	x	0.6	37.9	12.5	—	x0.02	0.01	0.4	0.04	1937	7.40	1211	1965	A.M.D.L.
1293	154.3	77.8	340	21	547.6	459.2	293.0	x	2.1	18.4	2.8	—	x0.02	0.651	0.5	x0.01	2841	7.55	1758	1965	A.M.D.L.
1294	90.5	50.3	219	12	323.4	245.7	206.6	x	0.9	37.5	87.9	—	x0.02	0.998	0.7	0.13	1900	7.75	1097	1965	A.M.D.L.
1295	59.5	21.6	17	20	14.7	16.9	321.0	x	0.8	60.5	28.5	—	x0.02	0.012	0.3	x0.01	563	7.70	284	1965	A.M.D.L.
2327	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1492	—	A.I.B.
2328	96.1	54.7	259	18	261.4	229.6	537.8	x	1.7	36.6	3.0	—	x0.02	0.002	0.5	0.04	1899	7.30	1181	1965	A.M.D.L.
2329	52.0	25.4	79	16	34.8	65.8	401.2	x	1.4	22.0	—	—	0.03	0.045	0.4	0.03	741	7.90	458	1965	A.M.D.L.
2330	78.0	46.1	115	51	71.3	77.0	651.4	x	2.4	61.9	9.3	—	x0.02	0.05	0.7	0.04	1248	7.30	781	1965	A.M.D.L.
2331	80.2	32.2	30	26	14.4	15.6	478.3	x	1.3	66.8	16.5	—	x0.02	0.045	0.3	0.02	600	7.60	471	1965	A.M.D.L.
2332	79.4	32.6	37	21	16.3	30.5	472.2	x	1.3	62.4	17.8	—	0.02	0.047	0.3	0.01	700	7.50	474	1965	A.M.D.L.
2333	52.7	27.1	139	34	47.5	119.3	487.9	x	2.1	48.0	16.5	—	x0.02	0.03	0.6	0.03	1059	7.50	690	1965	A.M.D.L.
2334	57.2	34.1	74	47	20.6	29.2	558.6	x	1.9	58.0	13.9	—	x0.02	0.035	0.5	0.03	875	7.55	577	1965	A.M.D.L.
4286	79.2	39.5	852	46	251.5	1533.7	415.8	x	5.6	13.6	3.8	—	x0.02	0.02	2.6	0.07	3882	7.50	2993	1965	A.M.D.L.
4305	210.7	1109.0	426	26	704.9	678.6	322.6	x	1.2	23.7	12.7	—	0.04	0.01	0.7	0.10	3494	7.40	2375	1965	A.M.D.L.
4521	57.3	22.6	142	24	87.8	167.4	317.9	x	1.6	51.1	31.5	—	0.02	0.021	0.7	0.02	1085	7.60	711	1965	A.M.D.L.
4522	135.7	74.5	916	19	970.0	1067.4	307.7	x	2.1	22.8	32.3	—	0.03	0.09	1.1	0.05	4992	7.70	3417	1965	A.M.D.L.
4601	49.2	27.6	27	2	17.0	25.9	339.5	x	0.3	76.9	3.6	—	0.02	0.021	0.1	x0.01	525	7.25	364	1965	A.M.D.L.
4602	33.5	27.2	68	3	45.2	21.0	333.5	x	0.4	34.5	6.8	—	x0.02	0.694	0.1	x0.01	652	7.45	294	1965	A.M.D.L.
4667	36.8	58.2	208	6	175.8	71.2	574.0	x	0.8	59.0	6.9	—	0.02	0.018	0.3	0.02	1430	7.35	864	1965	A.M.D.L.
4803	38.6	27.2	69	18	17.7	47.3	410.4	x	1.7	13.3	2.8	—	0.10	0.027	0.1	0.14	686	7.85	384	1965	A.M.D.L.
5671	135.7	78.0	234	31	467.3	227.1	404.7	x	0.7	25.6	12.3	—	x0.02	0.02	0.8	0.07	2289	7.30	1400	1965	A.M.D.L.
5675	86.1	42.9	760	26	566.2	857.6	354.9	x	3.0	29.0	39.6	—	0.02	0.038	1.1	0.05	3785	7.45	2528	1965	A.M.D.L.
5678	55.8	30.8	180	12	141.5	202.9	370.3	x	1.9	17.4	0.6	—	x0.02	0.016	0.6	0.05	1387	7.80	821	1965	A.M.D.L.
5679	62.5	22.7	12	21	5.9	9.5	339.5	x	0.8	61.1	23.8	—	x0.02	0.046	0.2	0.01	443	8.00	332	1965	A.M.D.L.
5680	58.1	28.2	42	42	11.8	18.5	450.6	x	1.8	51.1	10.8	—	x0.02	0.066	0.3	0.02	633	7.60	440	1965	A.M.D.L.
5682	54.5	25.0	60	19	22.2	37.9	401.2	x	1.7	47.0	14.7	—	x0.02	0.042	0.4	0.01	741	7.75	449	1965	A.M.D.L.
Wiggenty Well	17.1	17.6	46	5	55.5	17.7	148.1	x	0.4	72.9	13.9	—	0.02	0.07	0.1	x0.01	454	7.80	288	1965	A.M.D.L.
KATHERINE 1:250 000 SHEET AREA																					
1901	601.0	63.0	9	14	11.0	1538.0	191.0	x	2.4	18.0	x0.1	x0.01	0.03	0.03	0.2	0.16	2477	6.95	2404	1966	A.M.D.L.
*2522	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	729	7.38	450	1966	W.R.B.
2902	82.0	31.0	4.4	2.4	7.5	—	700.0	—	—	—	—	—	—	—	—	—	563	7.41	331	1966	W.R.B.
3025	64.0	—	—	—	12.0	—	266.0	—	—	—	—	—	—	—	—	—	735	7.08	337	1964	—
3027	40.0	—	—	—	11.0	—	270.0	—	—	—	—	—	—	—	—	—	779	6.96	428	1964	—
*4523	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	729	7.51	453	1966	W.R.B.
4524	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	559	8.56	524	1964	—
4525	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	660	8.14	568	1964	—
4600	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	779	6.96	428	1964	—
*4648	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	741	6.86	274	1965	W.R.B.
4709	5.64	0.99	—	—	6.0	24.0	277.0	x	x	—	x	—	—	0.6	—	—	—	6.91	518	1965	W.R.B.
*4881	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	675	7.44	395	1966	W.R.B.
*4886	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.85	409	1966	W.R.B.
*5042	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	675	7.38	442	1966	W.R.B.
*5082	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	680	7.30	417	—	—

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	Year	Laboratory
KATHERINE (continued)																					
5148	30.0	42.0	2.2	7.2	19.0	—	162	—	—	—	—	—	—	0.7	—	—	530	6.55	330	1966	W.R.B.
*5149	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1900	8.6	1039	—	—
*5329	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	578	7.38	436	1966	W.R.B.
LARRIMAH 1:250 000 SHEET AREA																					
* 551	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1427	—	A.I.B.
* 554	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	790	—	A.I.B.
554	103.0	47.0	80	8	115.0	69.0	495.0	x	x0.1	34.0	x0.1	0.02	x0.02	x0.01	0.2	0.01	1049	7.35	696	1966	A.M.D.L.
903	87.0	28.0	12	0.6	10.0	8.0	411.0	x	0.1	30.0	x0.1	0.01	0.03	0.06	0.1	x0.01	643	7.3	382	1966	A.M.D.L.
904	35.0	6.3	178	3	294.0	5.0	116.0	x	0.9	36.0	x0.1	0.01	0.02	0.04	2.5	0.14	1135	7.35	690	1966	A.M.D.L.
905	0.6	0.05	74	0.8	14.0	13.0	54.0	51	0.6	63.0	x0.1	0.02	x0.02	0.03	4.3	0.11	319	9.9	295	1966	A.M.D.L.
906	57.0	16.0	24	3	8.0	7.0	316.0	x	0.1	58.0	x0.1	0.02	0.38	0.03	0.1	0.07	484	7.4	335	1966	A.M.D.L.
2186	101.0	63.0	125	14	190.0	101.0	522.0	—	—	—	8.0	—	—	—	—	—	—	—	1124	—	A.I.B.
NEWCASTLE WATERS 1:250 000 SHEET AREA																					
218	30.0	23.0	135	49	20.0	21.0	566.0	x	2.5	63.0	7.3	0.01	x0.02	0.04	1.0	x0.01	951	8.0	657	1966	A.M.D.L.
515	111.0	61.0	171	16	249.0	157.0	465.0	x	0.7	44.0	10.1	0.01	x0.02	0.02	0.4	0.07	1753	7.3	1063	1966	A.M.D.L.
* 591	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2469	—	A.I.B.
* 591	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2860	1965	W.R.B.
592	121.0	75.0	367	58	459.0	305.0	629.0	x	1.1	44.0	6.1	x0.01	x0.02	0.01	0.6	0.08	2728	7.7	1787	1966	A.M.D.L.
907	57.0	77.0	340	84	355.0	234.0	698.0	—	1.4	—	7.0	—	—	—	—	—	—	—	1853	1953	A.I.B.
* 907	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1593	1965	W.R.B.
907	95.0	61.0	253	73	271.0	172.0	677.0	x	1.4	57.0	4.7	0.03	x0.02	0.01	0.6	0.04	2003	7.75	1309	1966	A.M.D.L.
1896	75.0	41.0	70	26	95.0	43.0	459.0	x	1.5	—	x	—	—	—	—	—	—	—	811	—	A.I.B.
1899	80.0	49.0	72	2.8	140.0	170.0	179.0	48	0.2	—	—	—	x	0.2	—	—	1150	7.94	768	1965	W.R.B.
2350	66.0	26.0	19	31	15.0	7.0	381.0	x	0.6	69.0	13.6	0.01	x0.02	0.05	0.2	x0.01	569	7.85	452	1966	A.M.D.L.
4579	89.0	58.0	237	73	244.0	146.0	677.0	x	1.3	55.0	3.8	0.01	x0.02	0.01	0.5	0.04	1948	7.7	1281	1966	A.M.D.L.
5686	74.0	47.0	78	58	79.0	24.0	569.0	x	1.1	69.0	6.1	0.03	x0.02	0.01	0.3	0.02	1069	7.8	695	1966	A.M.D.L.
5687	73.0	37.0	52	47	44.0	16.0	501.0	x	0.8	68.0	9.0	0.02	x0.02	0.02	0.2	0.01	914	7.35	575	1966	A.M.D.L.
5688	75.0	33.0	51	40	36.0	17.0	480.0	x	0.9	66.0	13.9	0.02	x0.02	0.01	0.2	0.01	876	7.3	553	1966	A.M.D.L.
5689	69.0	37.0	82	56	31.0	24.0	590.0	x	1.2	66.0	8.4	0.02	x0.02	0.07	0.3	0.02	1003	7.3	647	1966	A.M.D.L.
5690	61.0	33.0	37	39	20.0	11.0	453.0	x	1.0	66.0	7.8	0.03	x0.02	0.06	0.3	x0.01	732	7.75	475	1966	A.M.D.L.
5793	94.0	50.0	121	50	125.0	71.0	614.0	x	1.3	57.0	6.4	0.03	x0.02	x0.01	0.4	0.02	1415	7.65	872	1966	A.M.D.L.
TENNANT CREEK 1:250 000 SHEET AREA																					
505	558.0	220.0	225	32	323.0	2176.0	177.0	x	0.9	—	14.0	—	—	—	—	—	—	—	3666	—	A.I.B.
505	550.3	173.9	192	25	279.2	1916.4	157.4	x	2.8	19.4	7.7	—	—	0.032	0.7	0.50	3783	7.30	3307	1965	A.M.D.L.
1200	492.3	149.6	153	20	266.2	1574.8	243.8	x	2.8	19.2	11.6	—	0.02	x0.001	0.8	0.42	3162	7.10	2531	1965	A.M.D.L.
1201	142.1	75.6	186	36	329.3	183.1	518.4	x	1.3	37.3	12.6	—	0.08	0.036	0.3	0.03	2068	7.30	1230	1966	A.M.D.L.
1208	132.1	68.5	152	32	267.4	115.6	570.9	x	0.8	39.0	13.3	—	0.02	x0.021	0.3	0.05	1746	7.25	1057	1965	A.M.D.L.
4189	134.1	66.8	164	29	300.8	134.6	540.1	x	0.9	33.6	14.1	—	0.02	x0.001	0.4	0.07	1794	7.15	1100	1965	A.M.D.L.
4521	125.8	69.0	157	28	326.4	124.7	438.2	x	1.1	28.5	18.9	—	0.02	0.029	0.3	0.09	1891	7.40	1064	1966	A.M.D.L.

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	Year	Laboratory
VICTORIA RIVER DOWNS 1:250 000 SHEET AREA																					
512	98.0	33.0	8	3	5.0	3.0	478.0	x	1.9	—	2.0	—	—	—	—	—	—	—	632	—	A.I.B.
512	84.0	32.0	8	2	4.0	7.0	411.0	x	0.3	38.0	1.4	0.04	x0.02	0.03	x0.1	0.01	555	7.7	368	1966	A.M.D.L.
584	46.0	23.0	60	—	10.0	—	447.0	—	1.54	—	—	—	—	—	—	—	—	—	587	—	A.I.B.
584	49.0	20.0	59	0.8	7.0	24.0	376.0	x	0.5	65.0	x0.1	0.03	0.02	0.05	0.1	0.03	578	7.9	400	1966	A.M.D.L.
594	116.0	43.0	7	2	7.0	5.0	566.0	x	0.2	34.0	0.3	0.03	x0.02	0.07	x0.1	0.02	797	7.3	473	1966	A.M.D.L.
595	70.0	47.0	17	3	8.0	12.0	465.0	x	0.6	34.0	x0.1	0.04	x0.02	0.13	x0.1	0.07	674	7.65	392	1966	A.M.D.L.
*1091	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	305	1966	A.M.D.L.
1340	122.0	33.0	17	2	4.0	21.0	548.0	x	0.4	35.0	0.9	0.03	0.05	0.05	0.1	0.02	825	7.2	493	1966	A.M.D.L.
*1913	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	663	—	W.R.B.
1988	65.0	37.0	33	3	9.0	10.0	447.0	x	0.4	45.0	x0.1	0.02	0.07	0.01	0.3	0.06	699	7.35	411	1966	A.M.D.L.
3558	46.0	52.0	68	4	27.0	28.0	495.0	x	2.3	45.0	0.4	x0.01	x0.02	0.04	0.4	0.1	753	7.75	445	1966	A.M.D.L.
3747	134.0	21.0	4	1	2.0	13.0	507.0	x	0.1	27.0	x0.1	0.01	x0.02	x0.01	0.3	x0.01	740	7.0	444	1966	A.M.D.L.
3768	6.0	x1.0	65	x1	26.0	53.0	63.0	4	0.9	25.0	x0.1	0.01	x0.02	0.16	3.0	0.04	329	8.85	217	1966	A.M.D.L.
4049	1.5	0.06	137	0.3	9.0	17.0	313.0	13	0.4	40.0	x0.1	0.01	x0.02	0.09	0.5	0.05	547	9.0	367	1966	A.M.D.L.
4628	73.0	41.0	42	2	13.0	1.0	504.0	x	0.2	49.0	9.8	0.01	x0.02	0.03	0.2	0.01	768	7.3	456	1966	A.M.D.L.
4762	79.0	40.0	32	3	43.0	7.0	436.0	x	0.2	54.0	3.6	0.01	x0.02	x0.01	0.1	0.01	796	7.45	479	1966	A.M.D.L.
4763	63.0	28.0	44	2	4.0	7.0	435.0	x	0.3	59.0	6.5	0.02	x0.02	0.07	0.1	0.01	648	7.35	357	1966	A.M.D.L.
4764	78.0	21.0	9	4	5.0	21.0	349.0	x	0.4	43.0	2.0	0.02	x0.02	0.03	x0.1	x0.01	527	7.25	451	1966	A.M.D.L.
4765	61.0	42.0	41	0.7	20.0	4.0	465.0	x	0.3	62.0	7.3	0.04	x0.02	0.04	0.1	0.03	732	7.4	430	1966	A.M.D.L.
4769	59.0	51.0	67	1	9.0	x1.0	593.0	x	0.3	59.0	1.8	0.02	x0.02	0.08	0.1	0.01	855	7.3	502	1966	A.M.D.L.
5396	62.0	76.0	41	7.4	22.0	—	316.0	—	0.3	—	—	—	—	0.3	—	—	890	7.25	570	—	W.R.B.
*5423	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	484	—	W.R.B.
5424	11.0	60.0	68	3.0	20.0	—	201.0	34	0.2	—	—	—	—	0.2	—	—	330	8.15	433	1965	W.R.B.
5424	62.0	37.0	44	2	17.0	12.0	453.0	x	0.6	43.0	5.5	0.02	x0.02	0.04	0.1	x0.01	709	7.3	424	1966	A.M.D.L.
5426	79.0	40.0	44	2	14.0	17.0	519.0	x	0.5	50.0	7.5	0.02	0.02	0.05	x0.1	0.03	798	7.3	484	1966	A.M.D.L.
*5444	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	330	—	W.R.B.
5444	88.0	70.0	16	1	8.0	19.0	641.0	x	0.4	22.0	x0.1	0.01	x0.02	0.05	0.1	0.03	908	7.2	515	1966	W.R.B.
WAVE HILL 1:250 000 SHEET AREA																					
510	76.0	14.4	146	—	175.0	—	250.0	—	—	—	—	—	—	—	—	—	—	—	750	—	A.I.B.
583	33.0	61.0	57	1	15.0	—	505.0	—	0.44	—	2.0	—	—	—	—	—	—	—	674	—	A.I.B.
583	54.0	53.0	53	0.8	3.0	3.0	551.0	x	0.3	56.0	0.2	0.1	0.02	x0.01	0.1	0.01	809	7.7	500	1966	A.M.D.L.
585	60.0	51.0	58	1	75.0	—	588.0	—	—	—	9.0	—	—	—	—	—	—	—	843	—	A.I.B.
585	65.0	34.0	69	2	35.0	16.0	504.0	x	0.3	54.0	4.9	0.06	x0.02	0.09	0.1	x0.01	876	7.3	543	1966	A.M.D.L.
813	70.0	49.0	73	1	24.0	7.0	575.0	x	0.3	64.0	17.4	0.02	x0.02	0.11	0.1	0.01	906	7.55	566	1966	A.M.D.L.
814	21.0	7.0	107	1	27.0	11.0	322.0	x	0.2	46.0	1.0	0.01	0.02	0.05	0.2	0.01	581	7.9	400	1966	A.M.D.L.
815	39.0	30.0	170	3	77.0	21.0	545.0	x	0.4	65.0	3.0	0.03	x0.02	0.01	0.3	0.01	1068	7.55	700	1966	A.M.D.L.
817	54.0	37.0	74	3	37.0	8.0	426.0	x	0.3	60.0	43.7	0.02	x0.02	0.03	0.2	x0.01	804	8.0	523	1966	A.M.D.L.
* 818	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	360	—	A.M.D.L.
821	56.0	44.0	192	7	295.0	5.0	396.0	x	0.5	33.0	6.1	0.01	0.03	0.05	0.5	0.15	1557	7.75	847	1966	A.M.D.L.
838	63.0	33.0	119	2	68.0	27.0	495.0	x	0.3	74.0	11.2	0.02	x0.02	0.02	0.2	x0.01	994	7.4	651	1966	A.M.D.L.
841	78.0	45.0	39	1	16.0	3.0	516.0	x	0.3	54.0	15.4	0.02	x0.02	0.02	x0.1	x0.01	804	7.25	499	1966	A.M.D.L.
851	93.0	34.0	64	10	51.0	33.0	491.0	x	0.9	66.0	12.2	0.02	x0.02	0.01	0.1	0.02	952	7.2	595	1966	A.M.D.L.
852	187.0	118.0	223	28	562.0	152.0	599.0	x	1.5	79.0	5.8	0.02	x0.02	0.05	0.3	0.04	2753	7.0	1654	1966	A.M.D.L.
853	95.0	70.0	167	23	143.0	75.0	751.0	x	1.9	71.0	22.8	0.03	x0.02	0.03	0.3	0.04	1695	7.2	1016	1966	A.M.D.L.
1096	54.0	43.0	35	3	6.0	2.0	450.0	x	0.2	36.0	0.5	0.01	x0.02	0.01	0.1	0.01	685	7.2	399	1966	A.M.D.L.
1099	53.0	66.0	64	3	16.0	5.0	617.0	x	0.2	38.0	9.7	x0.01	x0.02	0.02	0.2	0.02	944	7.5	563	1966	A.M.D.L.
2337	111.0	74.0	82	17	64.0	43.0	748.0	x	1.5	61.0	12.0	0.04	x0.02	0.02	0.2	0.04	1279	7.3	811	1966	A.M.D.L.
2338	113.0	32.0	30	11	14.0	2.0	554.0	x	0.8	87.0	1.1	0.05	x0.02	0.03	0.1	0.01	812	7.25	569	1966	A.M.D.L.
2414	27.0	24.0	1.48	2.3	14.0	—	214.0	—	0.1	—	—	—	—	0.04	—	—	612	7.9	282	—	A.I.B.

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	Year	Laboratory
WAVE HILL (continued)																					
2836	48.0	38.0	136	3	101.0	51.0	432.0	x	0.5	68.0	14.7	0.03	x0.02	0.05	0.3	0.02	1061	7.55	676	1966	A.M.D.L.
4048	71.0	32.0	58	6	26.0	12.0	474.0	x	0.5	64.0	4.6	0.02	0.02	0.02	0.1	x0.01	772	7.4	492	1966	A.M.D.L.
*4303	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	478	1965	W.R.B.
4303	49.0	37.0	67	3	22.0	14.0	471.0	x	0.2	35.0	3.6	0.02	x0.02	0.05	0.1	0.03	751	7.55	451	1966	A.M.D.L.
4407	383.0	169.0	972	6	1828.0	975.0	253.0	x	0.4	38.0	6.4	0.02	0.04	0.07	1.3	0.08	7227	7.3	4594	1966	A.M.D.L.
4530	—	—	—	—	38.0	—	—	—	—	—	—	—	—	—	—	—	830	8.32	631	—	—
4531	—	—	—	—	36.0	—	—	—	—	—	—	—	—	—	—	—	625	8.37	436	—	—
4767	138.0	126.0	518	2	833.0	399.0	495.0	x	0.9	70.0	11.2	0.03	x0.02	0.06	0.5	0.01	3794	7.35	2399	1966	A.M.D.L.
WINNECKE CREEK 1:250 000 SHEET AREA																					
Hooker Ck No. 5	47.0	36.0	270	—	130.0	x	165.0	x	0.3	—	—	—	—	0.05	—	—	—	—	611	1965	A.I.B.
Hooker Ck No. 5	45.0	43.0	95	8	125.0	34.0	337.0	x	2.3	—	1.0	—	—	—	—	—	—	—	689	1957	W.R.B.
Hooker Ck No. 5	32.0	44.0	85	7	130.0	25.0	310.0	x	1.5	—	4.0	—	—	—	—	—	—	—	638	1957	W.R.B.
Hooker Ck No. 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	787	—	470	1967	W.R.B.
Hooker Ck No. 7	—	—	—	—	103.0	—	—	—	—	—	—	—	—	—	—	—	800	—	820	1964	W.R.B.
Hooker Ck No. 9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	611	8.14	424	—	W.R.B.
TANUMBIRINI 1:250 000 SHEET AREA																					
5845	119.0	52.0	64	9	95.0	150.0	450.0	x	0.6	24.0	x0.01	0.12	0.04	x0.01	0.48	x0.05	1121	7.45	690	1968	A.M.D.L.
5783	115.0	56.0	70	12	105.0	145.0	470.0	x	1.1	20.0	x0.01	0.14	0.02	0.01	0.30	x0.05	1252	7.50	774	1968	A.M.D.L.
*5942	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	900	7.9	568	1967	W.R.B.
*5954	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1150	7.45	637	1967	W.R.B.

APPENDIX 3. CHEMICAL ANALYSES OF BOREWATER

Percentage Reacting Values and Ionic Ratios

BEETALOO 1:250 000 SHEET AREA

Reg. No.	Na epm	K epm	Na + K epm	Na + K %	Ca epm	Ca %	Mg epm	Mg %	Sc epm	Cl epm	Cl %	SO_4 epm	SO_4 %	HCO_3 epm	HCO_3 %	Sa epm	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	Type
316	8.00	0.64	8.64	47	5.40	29	4.39	24	18.43	6.74	38	4.05	22	7.28	40	18.27*	0.78	0.81	0.60	1.08	1.13	0.59	CAnc
517	5.35	0.59	5.94	38	5.04	32	4.61	30	15.59	5.28	34	2.23	15	7.79	51	15.44*	0.89	0.91	0.42	1.48	1.62	0.67	CAnc
519	7.83	0.59	8.42	49	4.92	29	3.85	22	17.19	6.26	35	5.62	30	6.42	35	18.30	0.74	0.78	0.90	1.03	1.04	0.62	CAnc
522	10.35	0.33	10.68	59	3.58	20	3.75	21	18.01	7.67	41	5.85	31	5.36	28	18.89	0.72	1.05	0.76	0.70	0.69	0.61	ABn
1186	3.39	0.28	3.67	25	5.28	36	5.71	39	14.66	3.99	27	2.77	19	7.81	54	14.57	1.09	1.08	0.69	1.96	2.99	0.63	Cmc
1187	5.13	0.31	5.44	35	4.73	30	5.53	35	15.70	5.63	34	4.76	29	6.17	37	16.56	1.03	1.17	0.85	1.10	1.89	0.63	CAmn
1233	5.18	0.28	5.46	46	3.01	25	3.42	29	11.89	5.15	44	1.90	16	4.75	40	11.96*	0.94	1.14	0.37	0.92	1.18	0.58	ACnm
1290	13.75	0.72	14.47	60	5.52	23	4.12	17	24.11	9.79	39	8.89	35	6.63	26	25.31	0.68	0.75	0.91	0.68	0.67	0.63	ABn
1297	10.57	0.28	10.85	49	5.98	27	5.12	24	21.95	11.00	48	8.26	36	3.54	16	22.93*	1.01	0.86	0.75	0.32	1.02	0.64	ABn
1529	4.44	0.28	4.72	39	3.60	30	3.79	31	12.11	4.97	40	2.37	19	5.01	41	12.35	1.05	1.05	0.48	1.01	1.57	0.47	CAnm
1533	6.44	0.56	7.00	45	3.62	24	4.73	31	15.35	7.73	50	3.49	22	4.36	28	15.83*	1.10	1.30	0.45	0.56	1.19	0.61	Anm
1622	9.31	0.38	9.69	48	5.55	27	4.96	25	20.2	8.38	41	7.16	35	4.70	24	20.24	0.86	0.89	0.85	0.56	1.08	0.64	ABn
1623	2.26	0.33	2.59	19	5.44	39	5.91	42	13.94	3.34	25	4.66	34	5.56	41	13.56	1.29	1.09	1.40	1.66	4.38	0.65	CBmc
1888	5.66	0.41	6.07	39	5.04	33	4.38	28	15.49	6.31	40	4.76	30	4.59	30	15.66	1.04	0.37	0.75	0.73	1.55	0.64	ABnc
2165	15.87	1.02	16.89	69	2.50	10	5.02	21	24.41	6.51	27	5.35	22	12.39	51	24.36*	0.39	2.01	0.82	1.90	0.45	—	Cn
2348	6.26	0.61	6.87	43	4.73	29	4.56	28	16.16	6.13	37	3.11	19	7.39	44	16.63	0.89	0.96	0.51	1.21	1.35	0.59	CAnc
2351	6.44	0.61	7.05	41	5.48	32	4.72	27	17.25	6.15	36	3.09	18	8.09	47	17.51*	0.87	0.86	0.50	1.32	1.45	0.57	CAnc
2352	2.26	0.31	2.57	15	9.13	52	5.95	33	17.65	1.35	8	12.48	70	4.05	22	17.88	0.53	0.65	9.24	3.00	5.87	0.75	Bcm
2353	5.48	0.61	6.09	38	5.44	33	4.72	29	16.25	5.65	35	2.39	15	8.18	50	16.40*	0.93	0.87	0.42	1.44	1.67	0.33	CAnc
2381	12.92	0.59	13.51	52	6.44	25	5.84	23	25.79	10.37	40	8.73	34	6.73	26	25.83	0.77	0.91	0.84	0.65	0.91	0.68	ABn
3454	0.52	0.61	1.13	22	2.35	45	1.73	33	5.21	0.31	6	0.12	2	4.79	92	5.22	0.27	0.74	0.39	15.45	3.61	0.66	Cc
4695	4.74	0.28	5.02	41	3.55	29	3.59	30	12.16	3.85	31	3.07	25	5.41	44	12.33	0.77	1.01	0.80	1.41	1.42	0.63	CAnm
4912	4.87	0.54	5.41	36	5.16	34	4.61	30	15.18	5.51	35	2.19	14	8.09	51	15.95*	1.02	0.89	0.40	1.47	1.81	0.59	CAnc
4913	0.96	0.20	1.16	13	3.72	42	3.91	45	8.79	1.30	15	1.10	12	6.52	73	8.92	1.12	1.05	0.85	5.02	6.58	0.54	Cmc
4916	6.18	0.61	6.79	42	4.96	31	4.49	27	16.24	6.32	38	3.10	19	7.05	43	16.63*	0.93	0.90	0.49	1.12	1.39	0.30	CAnc
5432	1.18	0.26	1.44	17	3.48	41	3.63	42	8.55	1.04	13	0.39	5	6.88	82	8.31	0.72	1.04	0.38	6.62	4.94	0.67	Cmc
5433	16.53	0.84	17.37	53	8.65	26	7.06	21	33.08	12.70	38	11.36	34	9.10	28	33.16	0.70	0.81	0.89	0.72	0.90	0.68	ABn
5684	11.44	0.67	12.11	53	5.97	26	4.69	21	22.77	8.60	37	7.62	33	6.72	30	22.94	0.71	0.78	0.89	0.78	0.88	0.66	ABn

DALY WATERS 1:250 000 SHEET AREA

Reg. No.	Na epm	K epm	Na + K epm	Na + K %	Ca epm	Ca %	Mg epm	Mg %	Sc epm	Cl epm	Cl %	SO_4 epm	SO_4 %	HCO_3 epm	HCO_3 %	Sa epm	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	Type
557	10.22	1.07	11.29	51	5.49	24	5.51	25	22.29	8.74	39	4.29	19	9.64	42	22.67	0.77	1.00	0.49	1.10	0.97	—	
557	9.92	0.79	10.71	48	6.09	28	5.26	24	22.06	8.54	38	4.31	20	9.23	42	22.23*	0.80	0.86	0.50	1.08	1.06	0.64	CAnm
555	10.22	0.92	11.14	50	5.74	26	5.26	24	22.14	9.19	40	4.50	19	9.39	41	23.18*	0.82	0.92	0.49	1.02	0.99	—	
555	10.01	0.82	10.83	48	6.79	30	5.02	22	22.64	8.38	38	4.08	18	9.82	44	22.41*	0.77	0.74	0.49	1.17	1.09	0.64	CAnc
586	0.39	0.10	0.49	5	4.59	51	3.87	44	8.95	0.25	3	0.33	4	8.36	93	8.94	0.51	0.84	1.32	33.44	17.27	0.57	Ccm
587	0.09	0.07	0.16		2.74		2.55		5.45	0.23		—		3.31**		—	1.38	0.93	—	9.48	33.06	0.65	
587	0.70	0.13	0.83	9	5.29	56	3.29	35	9.41	0.79	9	0.33	3	8.11	88	9.23	0.93	0.62	0.42	10.27	10.34	0.59	Cc
588	0.87	0.20	1.07	16	0.95	15	4.52	69	6.54	0.99	15	0.25	4	5.75**	81	6.76	0.93	4.71	0.25	5.58	5.11	—	
588	0.65	0.15	0.80	9	5.29	57	3.13	34	9.22	0.71	8	0.46	5	8.06	87	9.23	0.89	0.59	0.65	11.35	10.53	0.60	Cc
589	0.09	0.08	0.17	3	2.94	53	2.47	44	5.58	0.06	1	0.06	1	5.43	98	5.55	0.35	0.84	1.00	90.5	31.82	0.72	Ccm
908	0.74	0.13	0.87		0.39		5.59		6.85	0.42		—		7.08		—	0.48	14.33	—	16.86	6.87	—	
908	0.61	0.08	0.69	8	4.19	46	4.28	46	9.16	0.28	3	0.31	3	8.46	94	9.05	0.39	1.02	1.11	30.21	21.28	0.58	Cc

* Includes epm attributable to NO_3^-; NO_3^- included under % Cl^-.

** Includes epm CO_3^-.

DALY WATERS (continued)

Reg. No.	Na epm	K epm	Na + K epm	%	Ca epm	%	Mg epm	%	Sc epm	Cl epm	%	SO_4 epm	%	HCO_3 epm	%	Sa epm	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	Type
1982	0.13	0.13	0.26	3	5.29	63	2.80	34	8.35	0.06	1	0.08	1	8.26	98	8.40	0.19	0.53	1.33	137.66	31.12	0.69	Cnc
2264	5.52	1.28	6.80	43	4.69	30	4.23	27	15.72	3.84	25	1.54	10	9.87	65	15.34*	0.56	0.90	0.40	2.57	1.31	0.68	Cnc
4518	0.57	0.18	0.75	10	3.99	51	3.13	39	7.87	0.14	2	0.48	6	7.23	92	7.85	0.19	0.78	3.43	51.64	9.49	0.66	Ccm
Daly Waters H.S.	9.40	0.77	10.17	46	7.04	32	4.93	22	22.14	8.23	38	4.04	18	9.72	44	22.09*	0.81	0.70	0.49	1.18	1.18	0.65	CAn
Natural Well ..	0.06	0.05	0.11	42	0.12	46	0.03	12	0.26	0.06	23	0.02	8	0.18	69	0.26	0.55	0.25	0.33	3.00	1.36	0.69	Ccn

DELAMERE 1:250 000 SHEET AREA

Reg. No.	Na epm	K epm	Na + K epm	%	Ca epm	%	Mg epm	%	Sc epm	Cl epm	%	SO_4 epm	%	HCO_3 epm	%	Sa epm	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	Type
1346	2.61	0.18	2.79	38	2.50	35	1.97	27	7.26	0.23	3	0.19	3	6.79	94	7.21	0.08	0.79	0.83	29.52	1.60	0.61	Cnc
4792	4.87	0.03	4.90	88	0.60	11	0.08	1	5.58	0.25	5	0.25	5	4.88	90	5.38	0.05	0.15	1.00	19.52	0.14	0.67	Cn
5402	4.26	0.05	4.31	—	1.25	—	3.29	—	8.85	0.36	—	—	—	4.11**	—	—	0.08	2.60	—	10.67	1.05	0.90	
5402	3.39	0.03	3.42	46	1.35	18	2.63	36	7.40	0.20	3	0.41	6	6.59	91	7.23	0.06	1.93	2.20	32.95	1.16	0.64	Cnm
5421	9.79	0.20	9.99	—	0.40	—	0.49	—	10.88	5.27	—	—	—	2.84	—	—	0.53	1.17	—	0.54	0.09	0.60	AC?
5459	8.05	—	—	—	0.80	—	1.81	—	—	1.27	—	—	—	2.34	—	—	—	—	—	1.84	—	0.97	
5544	1.17	0.08	1.25	20	2.56	41	2.47	39	6.28	0.65	10	0.06	1	6.02	89	6.73	0.53	0.96	0.09	9.26	4.02	0.63	Ccm

HELEN SPRINGS 1:250 000 SHEET AREA

Reg. No.	Na epm	K epm	Na + K epm	%	Ca epm	%	Mg epm	%	Sc epm	Cl epm	%	SO_4 epm	%	HCO_3 epm	%	Sa epm	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	Type
104	6.57	0.67	7.24	38	6.16	33	5.44	29	18.84	7.67	40	3.05	16	8.27	44	19.21*	1.06	0.88	0.40	1.08	1.60	0.64	CAnm
108	3.35	0.10	3.45	24	5.63	38	5.50	38	14.58	6.22	42	1.71	12	6.72	46	14.79*	1.80	0.98	0.27	1.08	3.23	0.57	CAcm
127	9.74	0.84	10.58	43	7.00	29	6.98	28	24.56	12.74	51	5.61	22	6.72	27	25.28*	1.20	1.00	0.44	0.53	1.32	0.62	Anc
134	7.9	0.79	8.69	39	7.38	33	6.46	28	22.53	9.95	44	4.15	18	8.50	38	22.85*	1.14	0.88	0.42	0.85	1.59	0.61	ACnc
140	38.28	0.59	38.87	50	22.29	28	16.84	22	78.00	47.88	61	26.52	34	3.91	5	79.81*	1.23	0.76	0.55	0.08	1.01	0.70	An
192	9.48	0.79	10.27	43	7.22	30	6.44	27	23.93	10.53	45	5.29	23	7.54	32	23.54*	1.03	0.89	0.50	0.72	1.33	0.64	ACnc
219	3.65	0.41	4.06	39	3.65	35	2.76	26	10.47	3.26	31	2.14	20	5.06	49	10.93	0.80	0.76	0.66	1.55	1.58	0.62	CAnc
237	23.71	0.77	24.48	66	7.19	19	5.40	15	37.07	17.95	48	13.33	36	5.77	16	37.91*	0.73	0.75	0.74	0.32	0.51	0.66	ABn
381	2.44	0.05	2.49	35	2.44	34	2.28	31	7.21	0.94	13	0.49	7	5.72	80	7.15	0.38	0.93	0.52	6.09	1.90	0.61	Cnc
418	2.74	0.28	3.02	34	2.84	32	2.94	34	8.80	1.03	12	0.60	7	7.08	81	8.71	0.34	1.04	0.58	6.87	1.91	0.54	Cnm
419	2.57	0.05	2.62	32	2.82	34	2.85	34	8.29	0.55	6	0.08	1	7.94	93	8.69*	0.21	1.01	0.15	14.44	2.16	0.62	Cmc
420	10.88	0.10	10.98	69	1.59	10	3.40	21	15.97	3.60	23	2.51	16	9.61	61	15.94*	0.33	2.14	0.70	2.67	0.45	0.64	Cn
520	6.79	0.49	7.28	61	2.45	21	2.21	18	11.94	3.94	31	3.03	23	5.97	46	12.94	0.51	0.90	0.77	—	0.64	—	CAn
521	10.22	0.59	10.81	45	7.32	31	5.84	24	23.97	10.62	42	10.30	40	4.55	18	25.47	0.98	0.80	0.97	0.43	1.22	0.63	ABnc
702	17.18	1.56	18.74	40	10.11	22	17.74	38	46.59	33.93	73	5.57	12	7.08	15	46.58	1.81	1.75	0.16	0.21	1.49	0.59	Anm
927	3.96	0.13	4.09	32	2.90	23	5.87	45	12.86	2.37	18	1.04	8	9.81	74	13.40*	0.58	2.02	0.44	4.14	2.14	0.65	Cmn
1193	6.53	0.74	7.27	37	6.69	34	5.90	29	19.86	7.87	39	2.75	14	9.31	47	20.14*	1.08	0.88	0.35	1.18	1.73	0.62	CAnc
1194	2.31	0.05	2.36	23	3.6	36	4.10	41	10.06	2.11	20	0.62	6	7.74	74	10.59*	0.89	1.14	0.29	3.67	3.26	0.54	Cmc
1199	7.05	0.79	7.84	39	6.71	33	5.73	28	20.28	8.60	43	2.87	14	8.72	43	20.44*	1.10	0.85	0.33	1.01	1.59	0.60	CAnc
1202	21.75	0.87	22.62	48	13.47	29	10.61	23	46.70	23.95	52	16.44	35	6.07	13	46.62*	1.06	0.79	0.69	0.25	1.06	0.70	ABnc
1203	18.71	0.67	19.38	35	21.6	39	14.10	26	55.08	21.68	39	30.43	54	4.00	7	56.34*	1.12	0.65	1.40	0.18	1.84	0.79	BAcn
1205	31.32	0.69	32.01	75	5.52	13	4.98	12	42.51	17.37	43	17.75	42	6.22	15	41.87*	0.54	0.90	1.02	0.36	0.33	0.70	ABn
1206	42.98	1.64	44.62	74	8.95	15	6.75	11	60.32	22.18	39	29.76	51	6.42	10	58.36*	0.50	0.75	1.34	0.29	0.35	0.70	BAn
1288	14.96	0.77	15.73	77	2.49	12	2.15	11	20.37	5.77	28	8.28	39	6.93	33	21.32*	0.36	0.86	1.44	1.20	0.29	0.61	BCn
1289	19.58	0.43	20.01	63	6.46	20	5.13	17	31.60	14.50	45	13.01	41	4.60	14	32.41*	0.72	0.79	0.89	0.32	0.58	0.64	ABn
1291	7.70	0.69	8.39	40	6.58	32	5.81	28	20.78	9.07	43	3.60	17	8.27	40	21.14*	0.69	0.88	0.40	0.91	1.48	0.63	ACnc
1293	14.79	0.54	15.33	52	7.70	26	6.40	22	29.43	15.44	52	9.56	32	4.80	16	29.80	1.01	0.83	0.62	0.31	0.93	0.62	ABn
1294	9.53	0.31	9.84	53	4.52	24	4.14	23	18.50	9.12	55	5.12	27	3.39	18	19.03*	0.93	0.92	0.56	0.37	0.88	0.58	An
1295	0.74	0.51	1.25	21	2.97	49	1.78	30	6.00	0.41	7	0.35	6	5.26	87	6.48*	0.33	0.60	0.85	12.83	3.8	0.50	Ccm
2328	11.27	0.46	11.73	56	4.80	23	4.5	21	21.03	7.37	35	4.78	23	8.81	42	20.96	0.63	0.94	0.65	1.20	0.79	0.62	CAn

Reg. No.	Na epm	K epm	Na + K epm	%	Ca epm	%	Mg epm	%	Sc epm	Cl epm	%	SO_4 epm	%	HCO_3 epm	%	Sa epm	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	Type
HELEN SPRINGS (continued)																							
2329	3.44	0.41	3.85	45	2.59	30	2.09	25	8.53	0.98	11	1.37	15	6.58	74	8.93	0.25	0.81	1.40	6.71	1.22	0.62	Cnc
2330	5.00	1.30	6.30	45	3.89	28	3.79	27	13.98	2.01	14	1.60	11	10.68	75	14.44*	0.32	0.97	0.80	5.31	1.22	0.63	Cnc
2331	1.31	0.67	1.98	23	4.00	46	2.65	31	8.63	0.41	5	0.32	4	7.84	91	8.84*	0.21	0.66	0.78	19.12	3.36	0.78	Ccm
2332	1.61	0.54	2.15	24	3.96	45	2.68	31	8.79	0.46	6	0.64	7	7.74	87	9.14*	0.21	0.68	1.39	16.83	3.09	0.68	Ccm
2333	6.05	0.87	6.92	59	2.63	22	2.23	19	11.78	1.34	11	2.48	21	8.00	68	12.09*	0.19	0.85	1.85	5.97	0.68	0.65	Cn
2334	3.22	1.20	4.42	44	2.85	28	2.80	28	10.07	0.58	6	0.61	6	9.16	88	10.57*	0.13	0.98	1.05	15.79	1.28	0.66	Cnc
4286	37.06	1.18	38.24	84	3.95	9	3.25	7	45.44	7.09	15	31.93	70	6.81	15	45.83	0.19	0.82	4.50	0.96	0.19	0.77	Bn
4305	18.52	0.66	19.18	50	10.51	27	9.12	23	38.81	19.86	51	14.14	36	5.29	13	39.49*	1.04	0.87	0.71	0.27	1.02	0.68	ABn
4521	6.18	0.61	6.79	59	2.86	25	1.86	16	11.51	2.48	25	3.49	30	5.21	45	11.68*	0.37	0.65	1.41	2.10	0.70	0.66	CBn
4522	39.85	0.49	40.34	76	6.77	13	6.13	11	53.24	27.35	51	22.22	40	5.04	9	55.11*	0.68	0.91	0.81	0.18	0.32	0.68	ABn
4601	1.17	0.05	1.22	21	2.46	41	2.27	38	5.95	0.48	7	0.54	8	5.56	85	6.58	0.39	0.92	1.13	11.58	3.88	—	Ccm
4602	2.96	0.08	3.04	44	1.67	24	2.24	32	6.95	1.27	18	0.44	6	5.47	76	7.29*	0.42	1.34	0.35	4.31	1.29	0.45	Cnm
4667	9.05	0.15	9.20	58	1.84	12	4.79	30	15.83	4.96	31	1.48	9	9.41	60	15.96*	0.54	2.60	0.30	1.90	0.72	0.60	Cn
4803	3.00	0.46	3.46	45	1.93	25	2.24	30	7.63	0.50	6	0.98	12	6.73	82	8.21	0.14	1.16	1.96	—	1.21	—	Cnm
5671	10.18	0.79	10.97	45	6.77	28	6.41	27	24.15	13.18	54	4.73	19	6.63	27	24.74*	1.20	0.95	0.36	0.50	1.20	0.61	Anc
5675	33.06	0.67	33.73	81	4.30	10	3.53	9	41.56	15.97	41	17.86	44	5.82	15	40.29*	0.47	0.82	1.12	0.36	0.23	0.67	BAn
5678	7.83	0.31	8.14	61	2.78	21	2.53	18	13.45	3.99	28	4.22	30	6.07	42	14.28	0.49	0.91	1.06	1.52	0.65	0.59	CBn
5679	0.52	0.54	1.06	18	3.12	51	1.87	31	6.05	0.17	9	0.2	3	5.56	88	6.31*	0.16	0.60	1.18	32.71	4.71	0.74	Ccm
5680	1.83	1.07	2.90	36	2.90	36	2.32	28	8.12	0.33	4	0.39	5	7.39	91	8.28*	1.10	0.80	1.18	22.39	1.80	0.70	Cnc
5682	2.61	0.49	3.10	39	2.72	35	2.06	26	7.88	0.63	8	0.79	10	6.58	82	8.24*	0.20	0.74	1.25	10.44	1.54	0.61	Cnc
Wiggenty Well ..	2.00	0.13	2.13	48	0.85	19	1.45	33	4.43	1.56	39	0.37	8	2.43	53	4.58*	0.73	1.71	0.24	1.56	1.08	0.63	CAnm
KATHERINE 1:250 000 SHEET AREA																							
1901	0.39	0.36	0.65	2	29.99	83	5.18	15	35.92	0.31	1	32.04	90	3.13	9	35.48	0.48	0.17	103.35	10.10	54.11	0.97	Bc
LARRIMAH 1:250 000 SHEET AREA																							
554	3.48	0.20	3.68	29	5.14	41	3.87	30	12.69	3.24	25	1.44	11	8.11	64	12.79	0.88	0.75	0.44	2.50	2.45	0.66	Ccm
903	0.52	0.02	0.54	8	4.34	60	2.30	32	7.18	0.28	4	0.17	2	6.74	94	7.19	0.52	0.53	0.61	24.07	12.30	0.59	Cc
904	7.74	0.08	7.82	78	1.75	17	0.52	5	10.09	8.29	81	0.10	1	1.90	18	10.29	1.06	0.30	0.01	0.23	0.29	0.61	An
905	3.22	0.02	3.24	99	0.03	1	0.0	—	3.27	0.39	12	0.27	8	2.59**	80	3.25*	0.12	—	0.69	6.64	0.01	0.92	Cn
906	1.04	0.08	1.12	21	2.84	54	1.32	25	5.28	0.23	4	0.15	3	5.18	93	5.56	0.21	0.46	0.65	22.52	3.71	0.69	Cc
2186	5.44	0.36	5.8	36	5.04	31	5.18	33	16.02	5.36	33	2.10	13	8.56	54	16.15*	0.92	1.03	0.39	1.60	1.74	—	Cnm
NEWCASTLE WATERS 1:250 000 SHEET AREA																							
218	5.88	1.25	7.13	68	1.50	14	1.89	10	10.52	0.56	5	0.44	4	9.28	91	10.40*	0.08	1.26	0.79	16.57	0.48	0.69	Cn
515	7.44	0.41	7.85	43	5.54	30	5.02	27	18.41	7.02	39	3.27	18	7.62	43	18.07*	0.89	0.91	0.47	1.09	1.35	0.61	CAnc
592	15.96	1.48	17.44	59	6.04	20	6.17	21	29.65	12.94	44	6.35	21	10.31	35	29.70*	0.74	1.02	0.49	0.80	0.70	0.66	ACn
907	14.79	2.15	16.94	65	2.84	11	6.33	24	26.11	10.01	38	4.87	19	11.44	43	26.42*	0.59	2.23	0.49	1.14	0.54	—	
907	11.01	1.87	12.88	57	4.74	21	5.02	22	22.64	7.64	34	3.58	16	11.10	50	22.32	0.59	1.06	0.47	1.45	0.76	0.65	CAn
1896	3.05	0.67	3.72	34	3.74	35	3.37	31	10.83	2.68	24	0.90	8	7.52	68	11.10	0.72	0.90	0.34	2.81	1.91	—	Ccn
1899	3.13	0.07	3.20	28	3.99	36	4.03	36	11.22	3.95	33	3.54	29	4.53**	38	12.02*	1.23	1.01	0.90	1.15	2.51	0.67	CAmc
2350	0.83	0.79	1.62	23	3.29	47	2.14	30	7.05	0.42	9	0.15	2	6.24	89	7.03*	0.26	0.65	0.36	14.86	3.35	0.79	Ccm
4579	10.31	1.87	12.18	57	4.44	21	4.77	22	21.39	6.88	33	3.04	14	11.10	53	21.08*	0.56	1.07	0.44	1.61	0.76	0.66	CAn
5686	3.39	1.48	4.87	39	3.69	30	3.87	31	12.43	2.23	19	0.50	4	9.33	77	12.16*	0.46	1.05	0.22	4.18	1.55	0.65	Cnm
5687	2.04	1.20	3.24	33	3.64	37	3.04	30	9.92	1.24	13	0.33	3	8.21	84	9.93*	0.38	0.84	0.27	6.62	2.06	0.63	Ccn

Reg. No.	Na epm	K epm	Na + K epm	%	Ca epm	%	Mg epm	%	Sc epm	Cl epm	%	SO_4 epm	%	HCO_3 epm	%	Sa epm	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	Type
NEWCASTLE WATERS (continued)																							
5688	1.74	1.02	2.76	30	3.74	41	2.71	29	9.21	1.02	11	0.35	4	7.87	85	9.46*	0.37	0.72	0.34	7.72	2.34	0.63	Ccn
5689	3.57	1.43	5.00	44	3.44	30	3.04	26	11.48	0.87	9	0.50	4	9.67	87	11.18*	0.17	0.88	0.57	11.11	1.30	0.65	Cnc
5690	1.70	1.00	2.70	32	3.04	36	2.71	32	8.45	0.56	7	0.23	3	7.42	90	8.34*	0.21	0.89	0.41	13.25	2.13	0.65	Ccm
5793	5.26	1.28	6.54	43	4.69	30	4.11	27	15.34	3.53	24	1.48	10	10.06	66	15.17*	0.54	0.88	0.42	2.85	1.35	0.62	Cnc
TENNANT CREEK 1:250 000 SHEET AREA																							
505	9.78	0.82	10.60	19	27.80	49	18.09	32	56.49	9.10	16	45.30	80	1.92	4	56.55*	0.86	0.65	4.98	0.21	4.33	—	
505	8.35	0.64	8.99	18	27.46	54	14.30	28	50.75	7.86	16	39.93	79	2.58	5	50.49*	0.87	0.52	5.08	0.33	4.65	0.87	Bc
1200	6.66	0.51	7.17	16	24.57	56	12.30	28	44.04	7.51	17	32.79	74	4.00	9	44.49*	1.05	0.50	4.37	0.53	5.14	0.80	Bc
1201	8.09	0.92	9.01	40	7.09	32	6.22	28	22.32	9.29	44	3.81	17	8.50	39	21.80*	1.03	0.88	0.41	0.91	1.48	0.59	ACnc
1208	6.61	0.82	7.43	38	6.59	34	5.63	28	19.65	7.53	40	2.41	12	9.34	48	19.49*	1.01	0.85	0.32	1.24	1.64	0.61	CAnc
4189	7.13	0.74	7.87	39	6.69	33	5.49	28	20.05	8.48	43	2.80	14	8.85	43	20.36*	1.08	0.82	0.33	1.04	1.55	0.61	CAnc
4521	6.83	0.72	7.55	39	6.28	32	5.67	29	19.50	9.20	49	2.60	14	7.18	37	19.28*	1.22	0.90	0.28	0.78	1.58	0.56	ACnc
VICTORIA RIVER DOWNS 1:250 000 SHEET AREA																							
512	0.35	0.08	0.43	5	4.89	61	2.71	34	8.03	0.14	2	0.06	1	7.83	97	8.03	0.33	0.55	0.43	55.93	17.67	—	
512	0.35	0.05	0.40	6	4.19	58	2.63	36	7.22	0.11	2	0.15	2	6.74	96	7.00	0.28	0.63	1.36	61.27	17.05	0.66	Ccm
584	2.61	—	2.61	—	2.30	—	1.89	—	—	0.28	—	—	—	7.33	—	—	0.11	0.82	—	26.18	1.61	—	
584	2.57	0.02	2.59	39	2.45	37	1.64	24	6.68	0.20	3	0.50	7	6.16	90	6.86	0.08	0.67	2.5	30.80	1.58	0.69	Cnc
594	0.30	0.05	0.35	4	5.79	60	3.54	36	9.68	0.20	2	0.10	1	9.28	97	9.58	0.57	0.61	0.50	46.40	26.66	0.59	Cc
595	0.74	0.08	0.82	10	3.49	43	3.87	47	8.18	0.23	3	0.25	3	7.62	94	8.10	0.28	1.11	1.09	33.13	8.98	0.58	Cmc
1340	0.74	0.05	0.79	8	6.09	64	2.71	28	9.59	0.11	1	0.44	5	8.98	94	9.53	0.14	0.44	4.00	81.64	11.14	0.60	Cc
1988	1.44	0.08	1.52	19	3.24	42	3.04	39	7.80	0.25	3	0.2	3	7.33	94	7.78	0.16	0.94	0.80	29.32	4.13	0.59	Ccm
3558	2.96	0.10	3.06	32	2.30	24	4.28	44	9.64	0.76	8	0.58	6	8.11	86	9.45	0.25	1.86	0.76	10.67	2.15	0.59	Cmn
3747	0.17	0.03	0.20	2	6.69	78	1.73	20	8.62	0.06	1	0.27	3	8.31	96	8.64	0.30	0.26	4.5	138.5	42.1	0.60	Cc
3768	2.83	0.00	2.83	90	0.30	10	0.00	—	3.13	0.73	24	1.10	38	1.16**	38	2.99	0.26	—	1.51	1.59	0.11	0.66	CBn
4049	5.96	0.01	5.97	99	0.07	1	0.00	—	6.04	0.25	4	0.35	6	5.56**	90	6.16	0.04	—	1.40	22.24	0.01	0.67	Cn
4628	1.83	0.05	1.88	21	3.64	41	3.37	38	8.89	0.37	6	0.02	—	8.26	94	8.81*	0.20	0.93	0.05	22.32	3.73	0.59	Ccm
4762	1.39	0.08	1.47	17	3.94	45	3.29	38	8.70	1.21	14	0.15	2	7.15	84	8.57*	0.82	0.84	0.12	5.91	4.92	0.60	Ccm
4763	1.91	0.05	1.96	26	3.24	43	2.30	31	7.50	0.11	3	0.15	2	7.13	95	7.49*	0.06	0.71	1.36	64.82	2.83	0.55	Ccm
4764	0.39	0.10	0.49	8	3.89	64	1.73	28	6.11	0.14	2	0.44	7	5.72	91	6.30	0.29	0.44	3.14	40.86	11.47	0.86	Cc
4765	1.78	0.02	1.80	22	3.04	37	3.45	41	8.29	0.56	8	0.08	1	7.62	91	8.38*	0.31	1.13	0.14	13.61	3.61	0.59	Cmc
4769	2.91	0.03	2.94	29	2.94	29	4.19	42	10.07	0.25	3	0.00	—	9.72	97	9.97	0.09	1.43	—	38.88	2.43	0.59	Cm(n?)
5396	1.78	0.19	1.97	—	3.09	—	6.25	—	11.31	0.62	—	—	—	5.18	—	—	0.31	2.02	—	8.35	4.74	0.64	
5424	2.96	0.08	3.04	—	0.55	—	4.93	—	8.52	0.56	—	—	—	4.42**	—	—	0.18	8.96	—	7.89	1.80	1.31	
5424	1.91	0.05	1.96	24	3.09	38	3.04	38	8.09	0.48	6	0.25	3	7.42	91	8.24*	0.24	0.98	0.52	15.46	3.13	0.60	Ccm
5426	1.91	0.05	1.96	21	3.94	43	3.29	36	9.19	0.39	4	0.35	4	8.51	92	9.37*	0.19	0.84	0.90	21.82	3.69	0.61	Ccm
5444	0.70	0.03	0.73	7	4.39	40	5.76	53	10.88	0.23	2	0.40	4	10.51	94	11.14	0.32	1.31	1.74	45.69	13.90	0.57	Cmc
WAVE HILL 1:250 000 SHEET AREA																							
510	6.35	—	6.35	—	3.79	—	1.18	—	11.32	4.94	—	—	—	4.10	—	—	0.78	0.31	—	0.83	0.78	—	
583	2.48	0.03	2.51	—	1.65	—	5.02	—	9.18	0.42	—	—	—	8.28	—	—	0.17	3.04	—	19.71	2.66	—	
583	2.31	0.02	2.33	25	2.69	29	4.36	46	9.38	0.08	1	0.06	1	9.03	98	9.17	0.03	1.62	0.75	112.88	3.03	0.62	Cmc
585	2.52	0.03	2.55	—	2.99	—	4.19	—	9.73	2.12	—	—	—	9.64	—	—	0.83	1.40	—	4.55	2.82	—	
585	3.00	0.05	3.05	33	3.24	36	2.80	31	9.09	0.99	10	0.33	4	8.26	86	9.66*	0.32	0.86	0.33	8.34	1.98	0.62	Ccn

Reg. No.	Na epm	K epm	Na + K epm	%	Ca epm	%	Mg epm	%	Sc epm	Cl epm	%	SO_4 epm	%	HCO_3 epm	%	Sa epm	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	Type
WAVE HILL (continued)																							
813	3.18	0.03	3.21	30	3.49	32	4.03	38	10.73	0.68	9	0.15	1	9.42	90	10.53*	0.21	1.15	0.22	13.85	2.34	0.62	Cmc
814	4.65	0.03	4.68	74	1.05	17	0.58	9	6.31	0.76	12	0.23	4	5.28	84	6.27	0.16	0.55	0.30	6.95	0.35	0.69	Cn
815	7.40	0.08	7.48	63	1.95	16	2.47	21	11.90	2.17	19	0.44	4	8.93	77	11.59*	0.29	1.27	0.20	4.12	0.59	0.66	Cn
817	3.22	0.08	3.20	36	2.69	30	3.04	34	8.93	1.04	12	0.17	2	6.98	78	8.89*	0.33	1.13	0.16	6.71	1.79	0.65	Cnm
821	8.35	0.18	8.53	57	2.79	19	3.62	24	14.94	8.32	55	0.10	1	6.49	44	15.01*	0.98	1.30	0.01	0.78	0.75	0.54	ACn
838	5.18	0.05	5.23	47	3.14	28	2.71	25	11.08	1.92	20	0.56	5	8.11	75	10.77*	0.37	0.86	0.29	4.22	1.12	0.65	Cnc
841	1.70	0.03	1.73	18	3.89	42	3.70	40	9.32	0.45	7	0.06	1	8.46	92	9.22*	0.26	0.95	0.13	18.80	4.39	0.62	Ccm
851	2.78	0.26	3.04	29	4.64	44	2.80	27	10.48	1.44	15	0.69	7	8.05	78	10.38*	0.47	0.60	0.48	5.59	2.45	0.63	Ccn
852	9.70	0.72	10.42	35	9.33	32	9.70	33	29.45	15.85	55	3.16	11	9.82	34	28.92*	1.52	1.04	0.20	0.62	1.83	0.60	Anm
853	7.26	0.59	7.85	43	4.74	26	5.76	31	18.35	4.03	24	1.56	9	12.31	67	18.27*	0.51	1.22	0.39	3.05	1.34	0.60	Cnm
1096	1.52	0.08	1.60	21	2.69	34	3.54	45	7.83	0.17	2	0.04	1	7.38	97	7.59	0.11	1.32	0.24	43.41	3.89	0.58	Cmc
1099	2.78	0.08	2.86	26	2.64	24	5.43	50	10.93	0.45	6	0.10	1	10.11	93	10.82*	0.16	2.06	0.22	22.47	2.82	0.60	Cm
2337	3.57	0.43	4.00	26	5.54	35	6.09	39	15.63	1.80	13	0.90	6	12.26	81	15.15*	0.45	1.10	0.50	6.81	2.91	0.63	Cmc
2338	1.31	0.28	1.59	16	5.64	57	2.63	27	9.86	0.39	4	0.04	—	9.08	96	9.51	0.23	0.47	0.10	23.28	5.20	0.70	Cc
2414	0.06	0.06	0.12	4	1.35	39	1.97	57	3.44	0.39	—	—	—	3.51	—	—	3.17	1.46	—	9.00	27.67	0.46	Cm
2836	5.92	0.08	6.00	52	2.40	21	3.13	27	11.53	2.85	28	1.06	9	7.08	63	11.23*	0.48	1.30	0.37	2.48	0.92	0.64	Cn
4048	2.52	0.15	2.67	30	3.54	40	2.63	30	8.84	0.73	8	0.25	3	7.77	89	8.82*	0.27	0.74	0.34	10.64	2.31	0.64	Ccn
4303	2.91	0.08	2.99	35	2.45	29	3.04	36	8.48	0.62	7	0.29	3	7.72	91	8.49*	0.21	1.24	0.47	12.45	1.84	0.60	Cmn
4407	42.28	0.15	42.43	56	19.11	25	13.90	19	75.44	51.55	68	20.30	27	4.15	5	76.10*	1.21	0.73	0.39	0.08	0.78	0.64	An
4530	—	—	—	—	—	—	—	—	—	1.07	—	—	—	—	—	—	—	—	—	—	—	0.76	
4531	—	—	—	—	—	—	—	—	—	1.02	—	—	—	—	—	—	—	—	—	—	—	0.70	
4767	22.53	0.05	22.58	57	6.89	17	10.36	26	39.83	23.49	59	8.31	21	8.11	20	40.09*	1.04	1.50	0.35	0.35	0.76	0.63	An
WINNECKE CREEK 1:250 000 SHEET AREA																							
Hooker Ck No. 5	11.74	—	—	—	2.35	—	2.96	—	—	3.66	—	—	—	2.70	—	—	—	1.26	—	0.74	—	—	
Hooker Ck No. 5	4.13	0.20	4.33	43	2.25	22	3.54	35	10.12	3.53	36	0.71	7	5.52	57	9.76	0.81	1.57	0.20	1.56	1.34	—	Cnm
Hooker Ck No. 5	3.70	0.18	3.88	43	1.60	17	3.62	40	9.10	3.67	39	0.52	6	5.08	55	9.27	0.95	2.26	0.14	1.38	1.35	—	CAnm
TANUMBIRINI																							
5845	2.78	0.23	3.01	23	5.93	45	4.28	32	13.22	2.68	20	3.13	24	7.38	56	13.19	0.89	0.72	1.17	2.75	12.6	—	Ccm
578	3.04	0.31	3.35	24	5.73	42	4.61	34	13.69	2.96	22	3.02	22	7.70	56	13.68	0.88	0.81	1.02	2.60	11.9	—	Ccm

APPENDIX 4. BMR SCOUTHOLES: GROUNDWATER PARAMETERS

Scouthole No.	Position	Elevation (m)	Total depth (m)	Aquifer	Depth of aquifers (m)	Depth standing water level (m)	Pump depth (m)	Supply l/s	Quality (ppm)	Remarks
				BEETALOO 1:250 000 SHEET AREA						
B 1	13 km at 10° from Ucharonidge	233	77	—	—	—	—	—	—	Dry hole
				DALY WATERS 1:250 000 SHEET AREA						
DW 1	11.5 km west by north of R.N. 1982	—	86	—	—	—	—	—	—	Dry hole
				GREEN SWAMP WELL 1:250 000 SHEET AREA						
GSW 1	87 km west of Tennant Creek	268	93	Merrina Beds	36 49 57	28	—	2.5	2330	—
GSW 2	16 km west of Tennant Creek	296	69	Merrina Beds	60	56	—	1.0	3203	—
GSW 3	137 km west-northwest of Tennant Creek	311	91	Merrina Beds	85	84	—	—	—	Only seepage
GSW 4	177 km west of Tennant Creek	241	170	Merrina Beds	6-44	3	—	7.5	2740	Saline at 44 m
GSW 5	209 km west-northwest of Tennant Creek	239	90	Merrina Beds	21 37	18	—	2.5	2831	—
				HELEN SPRINGS 1:250 000 SHEET AREA						
HS 1	38.1 km southwest of Eva Downs homestead	213	54	Anthony Lagoon Beds	47	42	—	1.0	1339	—
HS 2	11 km west of Helen Springs 1	—	40	—	—	—	—	—	—	Dry hole
HS 3	43.1 km northeast of Helen Springs homestead	210	69	Anthony Lagoon Beds	31 55	46	—	1.25	250	—
HS 4	23 km north-northeast of Helen Springs homestead	233	68	Anthony Lagoon Beds	62	—	—	—	421	—
HS 5	31.5 km southwest of Helen Springs homestead	238	39	—	—	—	—	—	—	Dry hole
HS 6	24.5 km south of Helen Springs homestead	296	30	Unconformity Gum Ridge Formation/ Helen Springs Volcanics	20	14	—	1.5	—	—
				KATHERINE 1:250 000 SHEET AREA						
K 1	54.4 km south of Katherine	154	131	Jinduckin Formation Jinduckin Formation Jinduckin Formation Tindall Limestone	30-32 67-75 88-91 108-128	 55	—	6.0	441 314 242 266	—
				LARRIMAH 1:250 000 SHEET AREA						
L 1	19 km north-northwest of Larrimah	—	30	—	—	—	—	—	—	Dry hole
L 2	61 km west by south of Larrimah	—	54	—	—	—	—	—	—	Dry hole
L 3	7 km southwest of Larrimah	—	46	Tindall Limestone	—	33	—	—	—	—

Scouthole No.	Position	Elevation (m)	Total depth (m)	Aquifer	Depth of aquifers (m)	Depth standing water level (m)	Pump depth (m)	Supply l/s	Quality (ppm)	Dry hole
				TANAMI EAST 1:250 000 SHEET AREA						
TE 1	109 km southeast of Wooker Creek	299	126	Merrina Beds	18 27	—	—	—	—	Seepage only
				WINNECKE CREEK 1:250 000 SHEET AREA						
WC 1	142 km east-southeast of Wooker Creek	—	53	—	—	—	—	—	—	Dry hole
WC 2	77 km southeast of Wooker Creek	—	73	—	—	—	—	—	—	Dry hole
WC 3	39 km east-southeast of Wooker Creek	—	49	—	—	—	—	—	—	Dry hole
WC 4	84 km east-southeast of Wooker Creek	—	54	—	—	—	—	—	—	Dry hole

APPENDIX 5. BMR SCOUTHOLES: ANALYSES OF GROUNDWATER
(Parts per million)

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	Year	Laboratory
									GREEN SWAMP WELL												
GSW 1	61	72	560	87	675	421	426	x	2.2	—	26	—	—	—	—	—	—	—	2330	1965	A.I.B.
GSW 2	89	91	830	98	895	904	283	x	3.5	—	9	—	—	—	—	—	—	—	3203	1965	A.I.B.
GSW 4*	32	39	290	45	360	235	160	x	0.6	—	24	—	—	—	—	—	—	—	1186	—	—
GSW 4**	378	71	380	61	455	1267	105	x	0.5	—	24	—	—	—	—	—	—	—	2740	—	—
GSW 5	108	184	575	315	1256	x	368	x	1.3	—	15	—	—	—	—	—	—	—	2831	1965	A.I.B.
									HELEN SPRINGS												
HS 1	20.1	27.2	400	41	175	2403	780.8	x	3.2	50.2	17.5	—	x0.02	0.036	1.1	0.05	2164	8.15	1339	1965	A.M.D.L.
HS 3	49.2	12.7	5	9	4.3	5.8	234.5	x	0.1	61.7	8.0	—	x0.02	0.048	0.5	x0.01	328	7.90	250	1966	A.M.D.L.
HS 4	49.9	25.7	62	5	73.7	39.5	296.3	x	0.7	50.0	3.6	—	x0.02	0.036	0.1	x0.01	684	7.85	421	1966	A.M.D.L.
									KATHERINE												
K1 (a)	31	84	28	25	31	32	524	x	0.8	21	x0.1	x0.01	x0.02	0.04	x0.1	0.11	825	7.9	441	1966	A.M.D.L.
(b)	35	54	31	16	14	19	429	x	0.8	26	0.3	0.03	x0.02	0.15	x0.1	0.05	641	7.85	345	1966	A.M.D.L.
(c)	31	39	7	8	3	17	295	x	2.2	22	x0.1	0.04	x0.02	0.15	x0.1	0.05	423	7.9	282	1966	A.M.D.L.
(d)	37	38	6	8	6	10	304	x	2.3	21	x0.1	x0.01	x0.02	0.07	x0.1	0.08	433	7.85	242	1966	A.M.D.L.
(e)	43	37	13	5	12	21	313	x	0.5	34	x0.1	x0.01	x0.02	0.01	x0.1	0.03	464	7.6	266	1966	A.M.D.L.

* Sample taken while casing still in hole.
** Sample taken after casing pulled from hole. Better quality water presumably comes from unrecorded aquifer below 44 metres.
(a) Sample taken during drilling at 32 m.
(b) Sample taken during drilling at 69 m.
(c) Sample taken during drilling at 71 m.
(d) Sample taken during drilling at 91 m.
(e) Sample taken during drilling at 123 m.

APPENDIX 6. BMR SCOUTHOLES: ANALYSES OF GROUNDWATER

Percentage Reacting Values and Ionic Ratios

Reg. No.	Na epm	K epm	Na + K epm	%	Ca epm	%	Mg epm	%	Sc epm	Cl epm	%	SO_4 epm	%	HCO_3 epm	%	Sa epm	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	Type
GREEN SWAMP WELL																							
GSW 1	24.36	2.23	26.59	75	3.04	9	5.92	16	33.55	19.01	55	8.77	25	6.98	20	34.76	0.71	1.95	0.46	0.37	0.34	—	An
GSW 2	36.11	2.51	38.62	76	4.44	9	7.48	15	50.54	25.21	52	1.83	39	4.64	9	48.68	0.65	1.68	0.75	0.18	0.31	—	ABn
GSW 4*	12.62	1.15	13.77	74	1.60	9	3.21	17	18.58	10.14	57	4.90	28	2.62	15	17.66	0.74	2.01	0.48	0.26	0.35	—	Anm
	16.53	1.56	18.09	42	18.86	44	5.84	14	42.79	12.82	31	26.40	65	1.72	4	40.94	0.71	0.31	2.06	0.13	1.37	—	Bcn
GSW 5	25.01	8.06	33.07	62	5.39	10	15.13	28	53.59	35.38	—	—	—	6.03	—	—	1.07	2.81	—	0.17	0.62	—	ABnm
HELEN SPRINGS																							
HS 1	17.40	1.05	18.45	85	1.00	5	2.24	10	21.69	4.93	22	5.01	22	12.80	56	22.74	0.27	2.24	1.02	2.60	0.18	0.62	Cnm
HS 3	0.22	0.23	0.45	11	2.46	62	1.04	27	3.95	0.12	3	0.12	3	3.84	94	4.08	0.27	0.42	1.00	32.00	7.78	0.76	Ccm
HS 4	2.70	0.13	2.83	38	2.49	34	2.11	28	7.43	2.08	27	0.82	10	4.86	63	7.76	0.73	0.85	0.39	2.34	1.63	0.62	Cnc
KATHERINE																							
K1 (a)*	1.22	0.64	1.86	18	1.55	15	6.91	67	10.32	0.87	9	0.75	7	8.59	84	10.21	0.47	4.46	0.86	9.87	4.55	0.53	Cmc
(b)	1.35	0.41	1.76	22	1.75	22	4.41	56	7.92	0.39	5	0.40	5	7.03	90	7.82	0.22	2.52	1.03	18.03	3.50	0.54	Cmc
(c)	0.30	0.20	0.50	10	1.55	29	3.21	61	5.26	0.08	1	0.35	7	4.84	92	5.27	0.16	2.07	4.38	60.50	9.52	0.67	Cmc
(d)	0.26	0.20	0.46	8	1.85	34	3.13	58	5.44	0.17	3	0.21	4	4.98	93	5.36	0.37	1.69	1.24	29.29	10.83	0.56	Cmc
(e)	0.57	0.13	0.70	12	2.15	36	3.04	52	5.89	0.34	6	0.44	7	5.13	87	5.91	0.49	1.41	1.29	15.09	7.41	0.57	Cmc

* Includes epm attributable to NO_3^- included under % Cl^-.

BULLETIN 123 - ADDENDUM

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Table Heading:- "Cu" should read "Al"

APPENDIX 7. AQUIFER ROCK ANALYSES

(In parts per million)

BMR Registered Sample No.	SiO_2	Cu	Fe	Mn	Ca	Mg	Na	K	Li	CO_3^-	SO_4^-	Cl–	F–	Ti	B	V	Sr	Pb	Zn	Co	Ni	PO_4
6667-0513 ..	903 000	19 044	5 883	232	2 619	3 317	307	18 677	4	5 863	600	200	120	1 739	50	25	30	18	20	35	25	307
0514	898 000	6 295	8 315	232	16 369	3 076	460	664	4	3 000	400	300	1 500	540	5	20	25	30	140	10	35	19 928
0516	952 000	12 432	2 440	77	1 310	905	—	747	—	2 045	100	100	20	959	3	8	30	40	25	8	—	307
0518	970 000	2 433	13 287	77	946	483	—	332	2	545	600	200	100	480	5	15	40	12	55	10	5	153
0729	888 000	14 019	4 484	77	12 804	8 263	153	12 784	2	30 681	500	100	200	719	50	25	20	15	20	8	5	307
0730	735 000	43 643	42 824	465	12 149	25 032	15 103	11 289	11	1 364	2 000	200	120	4 496	30	150	90	15	60	25	25	766
0730	538 000	75 118	66 762	1 007	29 828	44 635	26 450	15 722	5	6 818	600	100	150	6 894	50	200	140	20	90	35	45	1 073
0738	509 000	72 473	94 344	852	20 370	36 793	18 017	18 262	11	4 773	200	200	470	13 789	25	150	90	55	350	50	30	1 840
0738	507 000	79 350	81 642	542	14 550	47 952	27 600	25 733	9	5 727	400	—	470	8 453	25	150	80	25	120	40	55	1 533
0722	68 000	6 983	7 298	465	202 245	119 428	153	3 984	4	569 985	—	500	380	—	5	10	120	5	25	20	20	613
0722	221 000	18 515	13 110	387	162 233	89 872	307	17 432	4	436 352	—	400	590	—	25	15	70	15	25	20	15	307
0722	92 500	17 986	7 936	465	190 605	109 777	153	6 807	—	545 440	—	400	180	—	5	15	60	20	12	20	15	307
0722	61 000	4 444	6 901	465	202 245	121 840	77	3 403	2	586 348	—	400	90	—	3	15	60	15	18	20	20	307
0722	15 100	370	2 239	387	214 613	130 285	77	166	—	635 438	—	400	120	—	1	8	80	15	18	15	20	—
0732	11 000	635	7 787	155	393 578	3 921	153	166	—	582 257	450	400	90	—	1	1	100	20	20	20	35	307
0374	30 400	27 244	45 695	155	210 248	12 365	153	—	—	328 628	100	100	220	—	5	10	70	30	35	20	30	1 380
0734	16 000	1 957	8 572	77	347 745	33 778	77	332	—	582 257	—	400	—	—	1	6	70	25	30	20	30	307

0513—Helen Springs Scouthole No. 3, 182′-192′ (55-59 m), sandstone, Anthony Lagoon Beds.

0514—Helen Springs Scouthole No. 4, 200′-210′ (61-64 m), chert and clay, Anthony Lagoon Beds.

0516—Helen Springs Scouthole No. 6, 60′-70′ (18-21 m), claystone and sandstone, Helen Springs Volcanics.

0518—Beetaloo Southern Cross No. 1 bore, 270′-275′ (82-84 m), sandstone, Mullaman Beds.

0729—Wave Hill School Bore, 155′-156′ (47-47.5 m), calcareous sandstone, Victoria River Group.

0730—Shoeing Tool Replacement bore:
(a) 255′-275′ (78-84 m), basalt and quartz, Antrim Plateau Volcanics.
(b) 466′-490′ (142-149 m), basalt, Antrim Plateau Volcanics.

0738—Construction Bore DWH 3, Willeroo Road:
(a) 130′-140′ (40-43 m), basalt, Antrim Plateau Volcanics.
(b) 480′-492′ (146-150 m), amygdaloidal basalt, Antrim Plateau Volcanics.

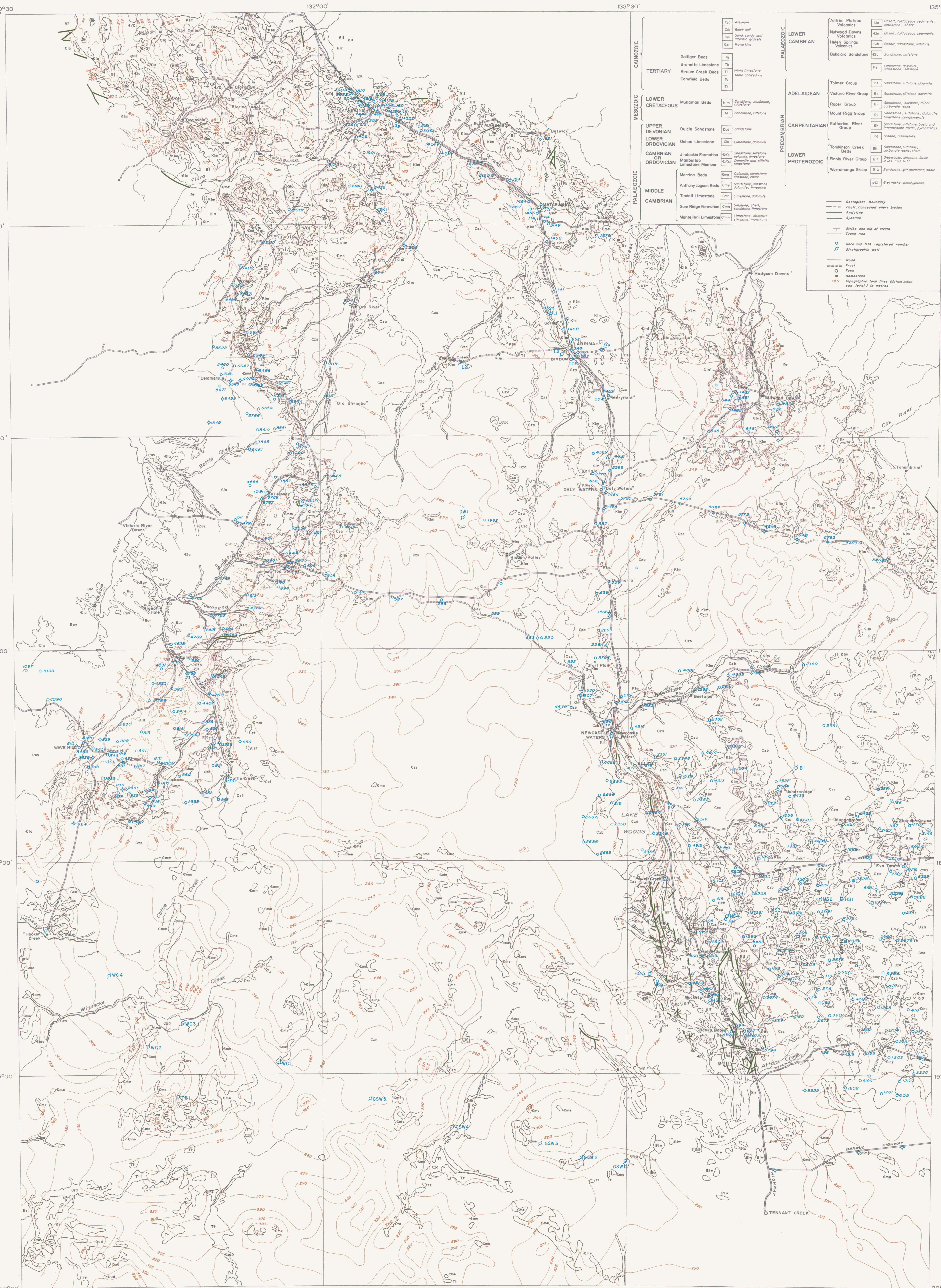
0722—Katherine Scouthole No. 1:
(a) 102′ 1″-102′ 8″ (31.11-31.29 m), dolomite, some siltstone, Jinduckin Formation.
(b) 220′-230′ (67-70 m), dolomite, some siltstone, Jinduckin Formation.
(c) 230′-240′ (70-73 m), dolomite, some siltstone, Jinduckin Formation.
(d) 290′-300′ (88-91 m), dolomite, some siltstone, Jinduckin Formation.
(e) 375′ 5″-375′ 9″ (114.4-114.5 m), dolomite, Tindall Limestone.

0732—Birrimba homestead bore (Widgee), 155′-156′ 1″ (47.2-47.5 m), limestone, Montejinni Limestone.

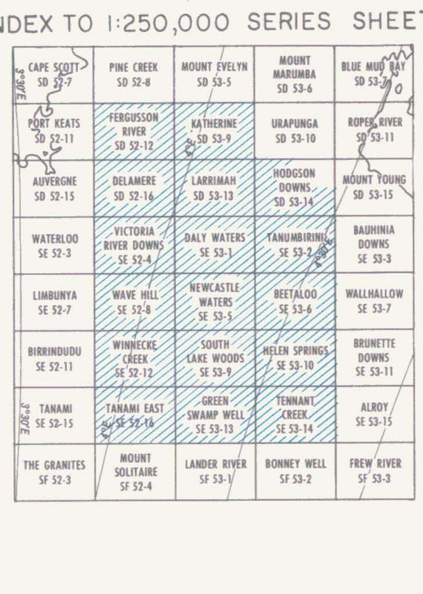
0734—Daly Waters Moorak bore:
(a) 196′-204′ (60-62 m), dolomitic limestone and weathered rubble, Tindall Limestone.
(b) 204′-220′ (62-67 m), limestone, Tindall Limestone.

GEOLOGY OF THE NORTHERN WISO BASIN AND ENVIRONS

PLATE 1



INDEX TO 1:250,000 SERIES SHEETS



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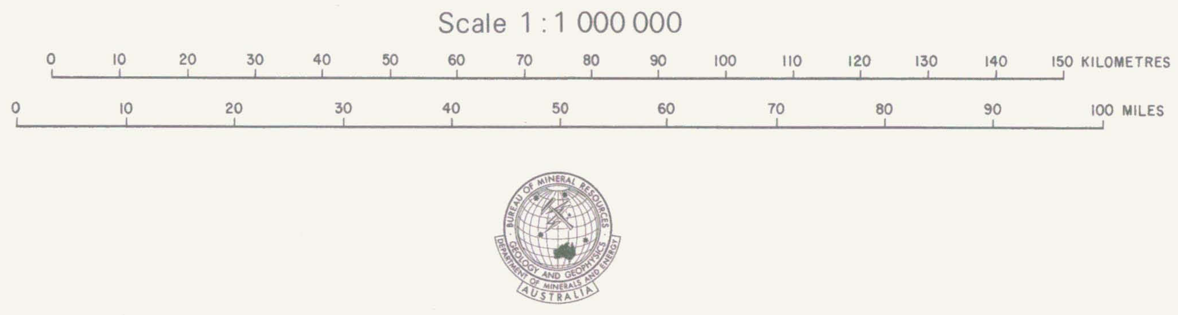

LAMBERT CONFORMAL CONIC PROJECTION

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