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Gulf Water Study

Dunmarra and Hodgson River Region

Australian Government
Water Smart Australia

Front cover:

Hodgson River Station

Drill chips from bore RN036471: (left to right) laterite from the surface, Cretaceous siltstone and Cambrian limestone.

Cattle: Cattle grazing is the main industry in the region.

GULF WATER STUDY

Cattle grazing is the main industry in the region

WATER RESOURCES OF THE DUNMARRA AND HODGSON RIVER REGION

REPORT 19/2009D

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DARWIN NT

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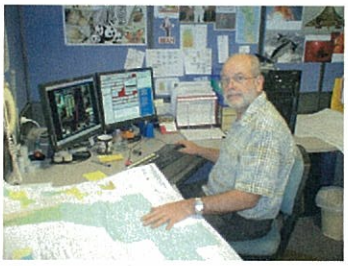
Special thanks to the station owners and managers who were generous with their time in providing key information on the region and were very hospitable: Rob and Bob Dunbar, Val Dyer, Ted Hart and Paul Zlotkowski.



Lynton Fritz

Technical working group

Drilling rig and crew.

SUMMARY

This report provides details of the groundwater and Dry season surface water resources of the Roper River region of the Gulf as depicted on the accompanying water resource map. It is one of five regions which make up the mapping area of the Gulf Water Study (Figure 1.1). The study was co-funded by the Australian Government Water Smart Australia Program and the Northern Territory Department of Natural Resources, Environment, the Arts and Sport.

The purpose of this work is to provide readily accessible and easily understandable information products on water resources in the region. The project was undertaken with the dual perspective of western science and indigenous knowledge and both are represented in the products of this study. The key aim is to provide a fundamental data set to guide development of water resources in the region maintaining healthy groundwater and rivers as well as the ecosystems which depend upon them.

The Dunmarra Hodgson River map region consists of six pastoral leases and cattle grazing is the main industry in the area. The level of water use is low.

In the Dunmarra Hodgson River region most surface water dries up by the end of the Dry season aside from one waterhole on Nutwood Downs station and a number of waterholes on Hodgson River station situated along the Hodgson River and its tributary the Arnold River. The region is heavily dependent on groundwater for domestic and stock use.

The groundwater resources have been classified into three aquifer types:

- Fractured and Karstic Rocks (yields up to 10 L/s)
- Fractured and Weathered Rocks (yields 0.5 – 5 L/s)
- Fractured and Weathered Rocks with minor groundwater resources (yields 0 - 1 L/s)

Fractured and karstic rock aquifers are the primary water resource for the region. The aquifers are situated in Cambrian aged limestone, which in this region, consists of the Anthony Lagoon Beds and the underlying Gum Ridge Formation. The Cambrian aged limestone presents an extensive aquifer system as it runs from Tennant Creek to Mataranka and covers most of the Dunmarra-Hodgson River region map. It is absent in the northern map area. The two Cambrian limestone formations lie beneath younger deposits ranging in thickness from 25 – 125m. The depth to the watertable has a similar range. Recorded airlift yields from the Cambrian limestone aquifers within the map region range from 0.3 – 25 L/s.

As part of the Gulf Water Study the Cambrian limestone aquifer system was modelled by Knapton using the computer based Feflow numerical groundwater model and a report is available (see Knapton, 2009). The aquifer discharges to the Roper River at Mataranka providing baseflow to the

river thereby maintaining ecosystems downstream. There is strong demand for water from this aquifer for agriculture and hence water allocation planning for the aquifer has commenced at Mataranka. The model will feed into this process and provide a guide to sustainable extraction limits of the aquifer.

The fractured and weathered rock aquifer is situated in sandstones located in the north of the map. Airlift yields are generally below 5 l/s.

Minor in extent are fractured and weathered rock aquifers with minor groundwater resources. These areas are in the north of the map. Only small yields, less than 1 L/s are anticipated from these aquifers.

Other products from the Gulf Water Study include a GIS, posters and photographic and video collection which are all available on DVD.

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There is a glossary in section 10 which provides a quick reference to scientific terms used in the report.

1. INTRODUCTION

This report provides details of the groundwater and Dry season surface water resources of the Dunmarra-Hodgson River region of the Gulf of Carpentaria as depicted on the accompanying water resource map. It is one of five regions which make up the mapping area of the Gulf Water Study (Figure 1.1). The study was co-funded by the Australian Government Water Smart Australia Program and the Department of Natural Resources, Environment, the Arts and Sport of the Northern Territory Government.

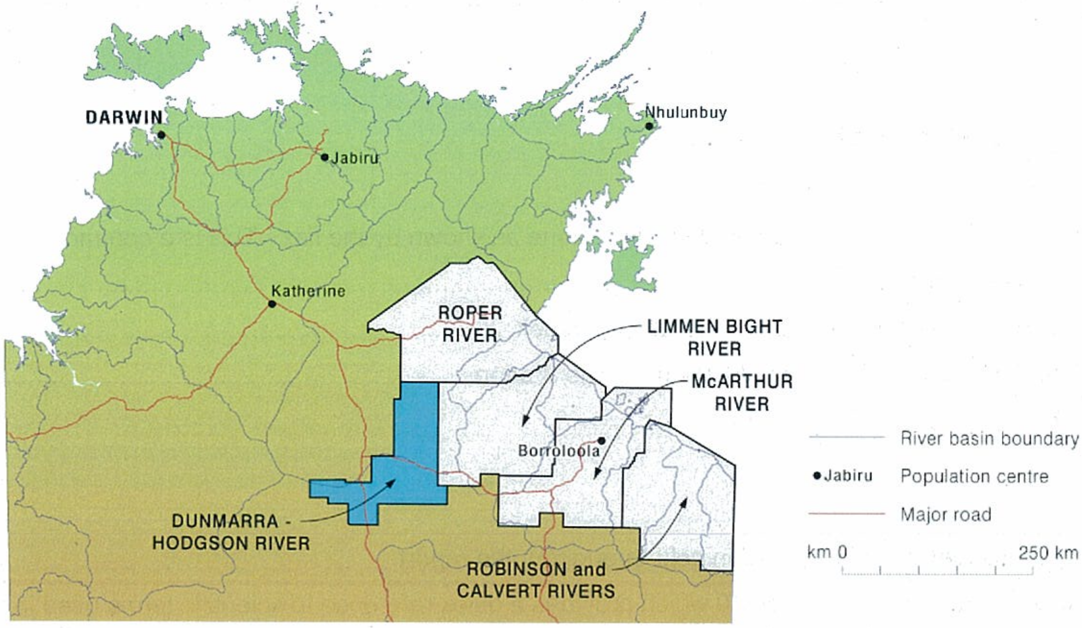


Figure 1.1 Study Regions

Ancillary to this report and map are posters, GIS and a photographic and video collection. All products from the study are available on DVD.

The purpose of this work is to provide readily accessible, easily understandable and user friendly information products on water resources in the region. The project was undertaken with the dual perspective of western science and indigenous knowledge however limited indigenous knowledge was gathered in this particular region. It has been targeted to inform all stakeholders from station managers through to water allocators and government bureaucrats. The key aim is to provide a fundamental data set to guide development of water resources in the region maintaining healthy groundwater and rivers.

The water resources map is an interpretation of the regions geology, topography, bore data, stream flows and vegetation patterns. Where data was lacking investigations were carried out including drilling, geophysical surveys and water quality sampling.

2. LOCATION

The region is dominated by six pastoral leases and cattle grazing is the main industry in the region. In the south east is the Bullwaddy Conservation Reserve.

Dunmarra is situated on the Stuart Highway. It is essentially a roadhouse supplying services to travellers. One Aboriginal outstation is located on Hodgson River Station. It is called Flicks Hole.

Access to the region is by the sealed Stuart Highway, the sealed Carpentaria Highway which runs from the Stuart Highway east to Borroloola, and the unsealed Buchannan Highway which leads west from the Stuart Highway. There is also a road which provides access to Hodgson River and Nutwood Downs Stations which runs off the Stuart Highway.

The headwaters of the Hodgson River lie on Nutwood Downs Station. The river drains from the south to the north where it eventually meets with the Roper River.

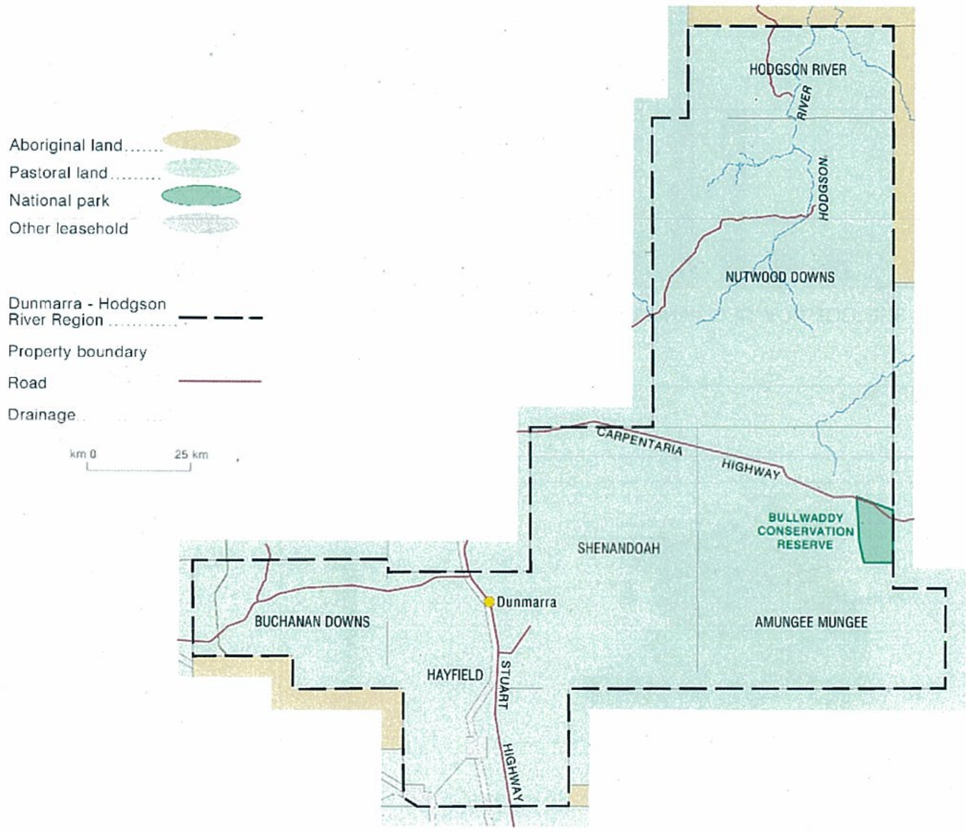


Figure 2.1 Land use in the Dunmarra and Hodgson River Region

3. CLIMATE

The region lies in the Wet/Dry tropics. With 6 months of negligible rain in the Dry season most streams cease to flow unless they are groundwater fed. Annual evaporation exceeds rainfall. The last decade has been the wettest for the period of record that is 118 years.

The region has a tropical savanna climate with a marked Wet season from November to April and Dry season from May to October (Figure 3.1). The region has an average annual rainfall between 600 - 800 mm per annum (Figure 3.2). There can be wide variations in annual rainfall. For example at Nutwood Downs[1], DR014621 (Figure 3.3) the long term average annual rainfall is 679 mm yet in the last decade the average has been 938 mm. This trend in rainfall has been observed throughout the Top End of the Northern Territory.

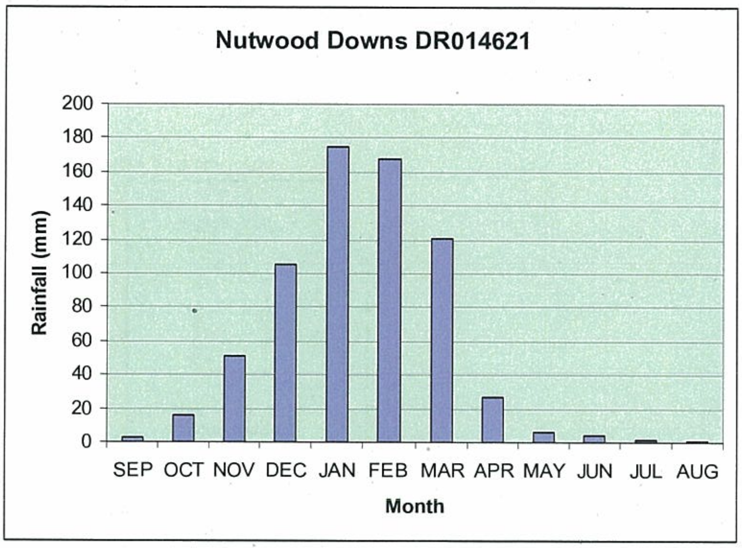


Figure 3.1 Average monthly rainfall for Nutwood Downs (Station Number DR014621)
(Data consists of original Bureau of Meteorology (BOM) data from DR014621 Nutwood Downs with interpolated data used to fill any gaps in the observation record. From SILO Patched Point data made available by the State of Queensland through the Department of Natural Resources.)

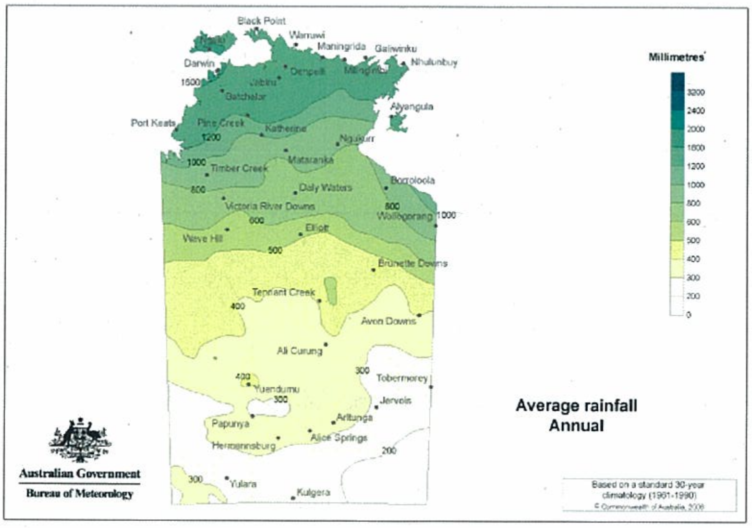


Figure 3.2 Average annual rainfall for the Northern Territory
(From BOM website: www.bom.gov.au/jsp/ncc/climate_averages/rainfall)

[1] There are a number of rainfall recorder sites in the region. A list is provided in Appendix H.

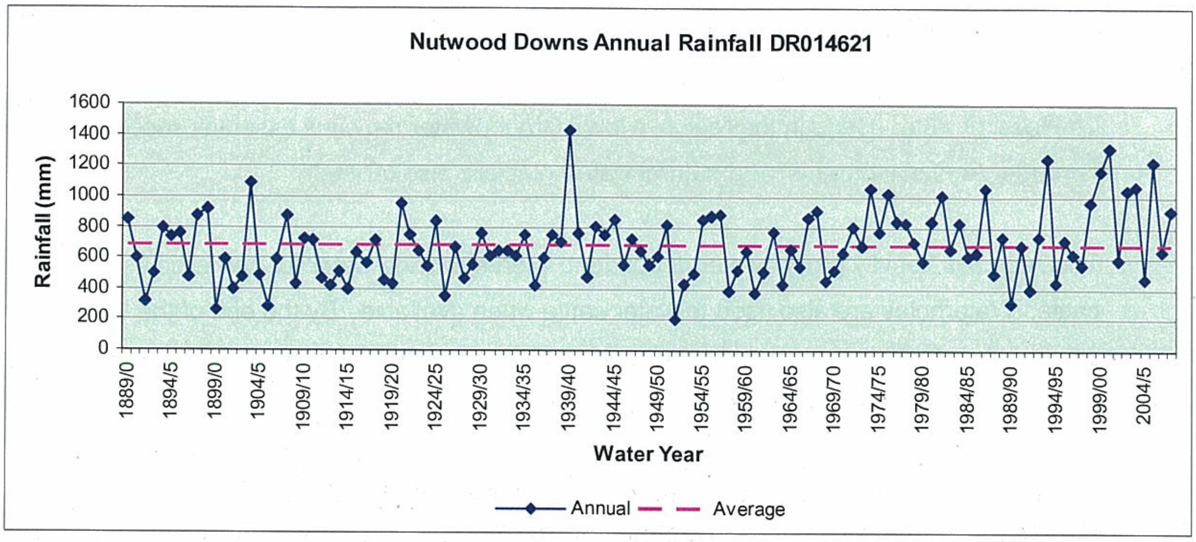


Figure 3.3 Nutwood Downs annual rainfall.
Calculated over the Water year = September to August of the following year. (This rainfall data consists of original Bureau of Meteorology (BOM) data for DR014621 Nutwood Downs with interpolated data used to fill any gaps in the observation record. It has been obtained from SILO Patched Point data made available by the State of Queensland through the Department of Natural Resources; www.longpaddock.qld.gov.au/silo).

Mean monthly minimum temperature varies from 12 - 24°C and maximum from 29 – 38°C. Average annual evaporation is about 2400 mm for the region which exceeds the annual rainfall in even the wettest of years. Mean monthly 3 pm humidity varies from 18 – 48 percent.

The Wet/Dry season contrast has significant implications for water resources. The monsoon brings wet season rainfall but cyclones, and the lows before and after cyclones, bring large rainfall events (Figure 3.4). 19 cyclones passed within 200 km of Dunmarra for the period 1906 to 2006, six of which occurred in the last decade. These events cause major flooding and can provide good recharge to aquifers. Although the Wet season brings significant rainfall over a short period, the ensuing Dry, with months of no rain, results in all rivers in the region ceasing to flow.

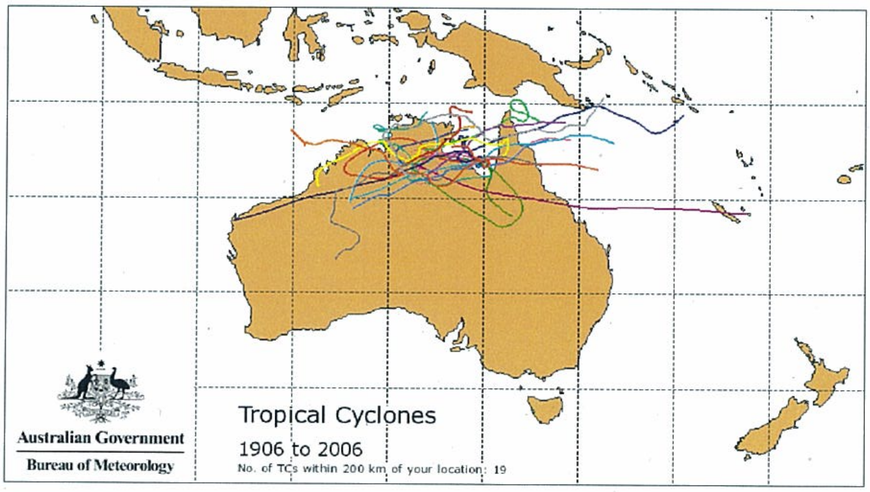


Figure 3.4 Tropical cyclones between 1906 – 2006 within 200 km of Dunmarra.
(From BOM website: www.bom.gov.au/cgi-bin/silo/cyclones)

4. CURRENT WATER USAGE

The level of water usage in the region is low. Groundwater provides essential supplies, however, rainwater (tanks and dams) and natural waterholes are also utilised.

This region is heavily groundwater dependent. Bores provide water for domestic usage and to water cattle. Waterholes are also used to water cattle when available. By the end of the Dry season almost all natural surface water has dried up outside of one waterhole on Nutwood Downs station and a number of waterholes on Hodgson River Station.

Table 4.1 Current water use in the Dunmarra-Hodgson River Area

Location	Domestic Water Supply	Water supply to cattle
Hodgson River Station	Bore	Bores, waterholes when available
Nutwood Downs Station	Bore	Bores, dams
Amungee Mungee Station	Bore	Bores, dams
Hayfield-Shenandoah Station	Bore	Bores, dams, waterholes when available
Buchanan Downs Station	Bore	Bores, dams
Flicks Hole (outstation)	Bore	

5. INDIGENOUS KNOWLEDGE

This project aims to present an understanding of water resources from a scientific and indigenous perspective. In doing so, it is hoped that common understandings will develop between Indigenous people and land managers about water in the region. Limited indigenous knowledge has been collected for this map region. The region has been referred to by indigenous elders from Minyeri, Ngukurr and Borroloola. To provide some understanding to the information these people provided, a brief overview of the indigenous world view follows[2].

Indigenous people are connected to their land through a culture that has survived for thousands of years. For them effective management of healthy groundwater and rivers often goes beyond the physical and into the cultural/spiritual realm. Indigenous people believe that the Spirit Ancestors created their environment as well as a charter that is the law for existence and through this law all land, water, plants, animals, natural pehenomena, people and the Spirit Ancestors (Dreamings) are inextricably connected (Bradley et al. 2006). It is through these intricate connections that indigenous people relate to water and everything else. Water sites not only have a physical entity and a purpose in the connected environment but can also be of social, emotional, cultural and spiritual significance. Effective management of land and water therefore involves consideration of all these realms. The following information offered by indigenous elders provides some insight to the significance of water in this map region.

Stephen Roberts

Stephen Roberts is an elder of the Budal clan. He lives at Minyerri. He was born in 1925 and experienced a traditional upbringing, learning about, and living his culture as it was for thousands of years. He also saw the changes that came with the Europeans. In talking with Stephen one quickly recognises that he has an extensive knowledge of the waterholes over a vast tract of country as he relates the names and dreamtime stories of waterholes and their interconnections. The following dreaming story tells of the journey of a group of mermaids. The last section relates to this map region.

The journey of a big mob of mermaids.

The mermaids came from Burrunju and travelled to Nyawurlbarr. From there they travelled to Wallanji swamp, then crossed the Roper River to another swamp located at the side of a hill and then on to Wurdawawa where they created the swamp and stayed for a while. Wurdawawa is an important swamp where ceremonies are held. They continued on to Rocky Crossing, the old wagon crossing on the Hodgson River where a footprint was left, then travelled up the Hodgson River to Wangananji. They met up with the quiet snake there and then went separate ways. There is a lot of black rock there which is related to the crow. The quiet snake went south and made a whirlwind. The mermaids continued to Nyardangarina and Injawan which is a permanent waterhole on the Hodgson River. They

[2] A more detailed overview is provided in the reports for the other regions.

then went to Jawalada, known as Grassmere Billabong, then to Wadamada waterhole on the Hodgson River. Their travels continued to Alinginji where there is a spring, Mardugurru, Wurrunnalda at Mc Donald lagoon, then to the bottom of Minimere waterhole, a place called Yunbulloy, back to Mc Donald lagoon, up a gorge to an island Yaldjamandja, to Narliboy Creek and on to Injay waterfall at Hodgson River station. As they danced there they made the waterfall. They danced on the Yindiyindi plain. Their journey finished upstream from Nutwood Downs Station, the Hodgson River being the last part of their journey. The mermaids made these places, they mark the path of the mermaids.

The Red legged Jabiru

The Red legged Jabiru started from Marlringa, a swamp near Old Newcastle Waters near Elliot and then went to Minimere. From Minimere it travelled to different places but its journey ended at Spring Creek Station. (Minimere is a waterhole on Hodgson River station and Spring Creek station is south of Borroloola)

Walter Rogers

Walter is a key elder people refer to for the Ngukurr region. He travelled with the study team around Ngukurr guiding them to waterholes and springs, naming the places and explaining cultural aspects. The following story had a connection to Nutwood Downs.

Warawu – Lake Katherine. (This waterhole is located about 60 km north-east of Ngukurr.) This is sugarbag and wild bee dreaming. The sugarbag flew from here to Nutwood (Downs) and created the spring there at the homestead. That spring relates to the sugarbag.

Les Hogan (warramurru) and Bruce Joy

The project team caught up with Les and Bruce at Cow Lagoon which is an outstation out of Borroloola. Les is a senior Garrwa ceremony man and Bruce is a Gudanji elder. They also told the story of the Red Legged Jabiru but from the Garrwa perspective.

The Red Legged Jabiru

The red legged Jabiru stopped at Spring Creek Station. This bird came from the west. It came from Stephen Roberts' country on the Roper River and came across. Minimere is the name of the jabiru in the Alawa language. Minimere is on the Hodgson River.

6. GROUNDWATER

6.1 The Water Cycle

To understand the groundwater system, it helps to have an understanding of the water cycle (Figure 6.1). When rainfall hits the ground, some of it runs off into streams and creeks (surface runoff), some of it evaporates and some of it seeps into the ground (infiltration). The amount of water that infiltrates depends on many factors, including the soil and rock type, the slope of the land and the intensity and duration of rainfall. As the water infiltrates it wets up the soil and moves down. Some of this water will be evaporated or used by plants, and the rest will move downwards until it reaches the watertable to become groundwater. The process of adding water to the groundwater system is called recharge. Porous rocks and soil allow the groundwater to slowly move from high areas to low areas, usually discharging to the surface at some point. If a useful amount of water can be extracted from a rock, then it is referred to as an aquifer.

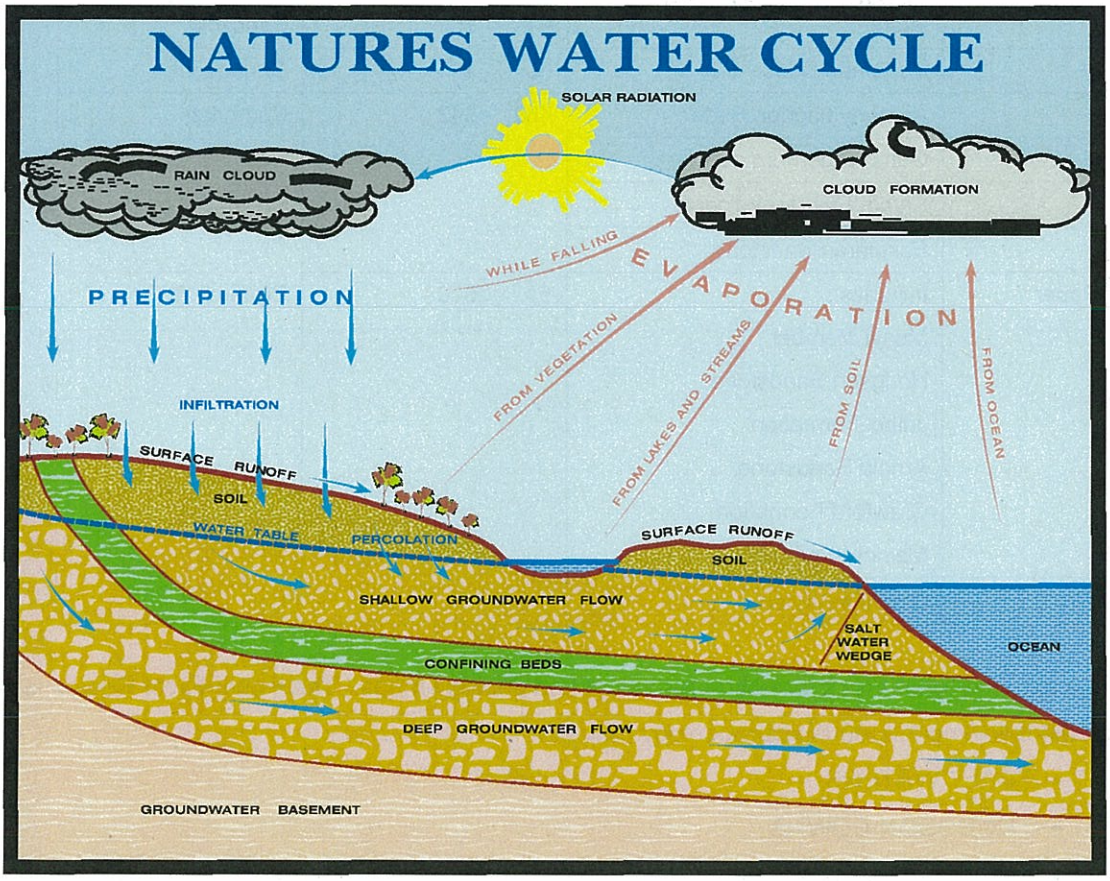


Figure 6.1 The Water Cycle

6.2 Geology

Geology is the science of rocks and their characteristics. Rock type and geological structure are some of the main factors influencing groundwater occurrence and the location of springs.

6.2.1 Rock Formations

Rock formations are made up of one or several rock types. These are shown on geology maps. The groundwater potential of each formation is assessed and those with similar aquifer characteristics are grouped together and mapped under one of the aquifer types shown on the water resources map.

Rocks are classified into rock formations as characterised by their physical and chemical features. Rock formations can consist of one or several rock types i.e. sandstone, dolomite. When a number of rock formations have common characteristics, they are grouped together to form a rock group. The age of the rock is categorised by a geologic time frame. Table 6.1 provides a broad outline of the rock groups and formations of the region and their ages.

Table 6.1 Rock groups, Formations and their ages.

GROUP	ROCK FORMATION	AGE: IN MILLIONS OF YEARS	GEOLOGIC TIME FRAME
	Alluvium, black soil, sand, laterite	0 - 65	Cenozoic
	Mullaman Beds	65 - 145	Cretaceous
	Anthony Lagoon Beds	488 - 542	Cambrian
	Gum Ridge Formation		
	Antrim Plateau Volcanics		
	Bukalara Sandstone		
Roper	Includes: Munyi Member Hodgson Sandstone Jalboi Formation Arnold Sandstone Crawford Formation Mainoru Formation	542 - 2500	Proterozoic
	Undifferentiated		

The extent of each Rock formation is depicted on geology maps. The Roper River Region is covered by the following 1:250000 scale geology maps:

- DALY WATERS
- HODGSON DOWNS
- NEWCASTLE WATERS
- TANUMBIRINI

A number of the Rock formations noted in Table 6.1 will be referred to in this report. The groundwater potential of each formation has been assessed and formations with similar aquifer characteristics are grouped together under one of the aquifer types. The geology maps, which show the area covered by each formation, are used to map out the area of each aquifer type shown on the water resource map

(Figure 6.2). Put simply, formations with similar aquifer characteristics are mapped together under one of the aquifer types. Aquifer type delineates the groundwater resources on the water resource map.

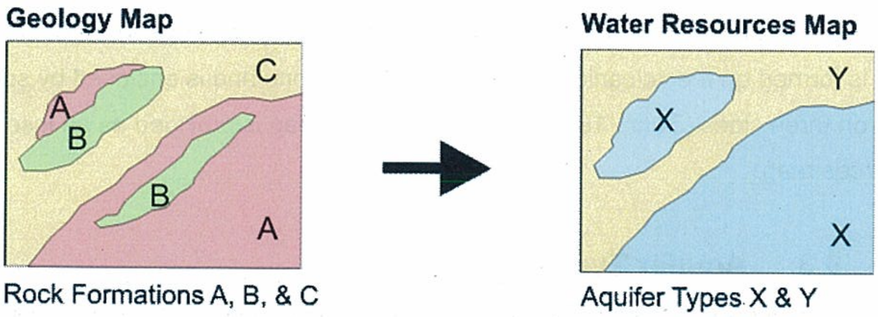


Figure 6.2 **Example of grouping of Rock formations into aquifer type.** Here formations A and B have similar aquifer characteristics whereas formation C is different.

6.2.2 Geologic Structure and depositional history

The oldest rocks are the Proterozoic rocks which consist of sandstones, siltstones and mudstones of the Roper Group (Table 6.1). They outcrop largely on eastern Hodgson River Station and north-eastern Nutwood Downs Station. West of these areas, the Roper Group is overlain by the Bukalara Sandstone. It outcrops across the centre of Hodgson River Station and northern Nutwood Downs Station. The Antrim Plateau Volcanics overlies the Bukalara Sandstone and outcrops over a similar area. From here the Antrim Plateau Volcanics dips to the south forming the basement for the overlying limestone which extends over most of the map region. There is a north-south trending basement high situated through the centre of Hayfield Station which divides the Cambrian limestone into two basins; the Wiso Basin to the west and the Georgina Basin to the east. In southern Hayfield Station the Volcanics have not been intersected. The extent and elevation of the Antrim Plateau Volcanics is presented in an inset on the map.

The Cambrian limestone consists of the lower Gum Ridge Formation and upper, younger, Anthony Lagoon Beds. The Gum Ridge Formation consists of limestone, fine grained sandstone and siliclastic mudstone and nodular chert. The Anthony Lagoon Beds also contains limestone but is dominated by beds of dolomitic siltstone. The Gum Ridge Formation is actually the name given to the lower Cambrian limestone unit in the Georgina Basin. The time equivalent unit in the Wiso Basin is called the Montejinni Limestone and is very similar to the Gum Ridge Formation. For the purposes of this study no distinction is made between the formations and they are referred to as the Gum Ridge Formation. Similarly the Anthony Lagoon Beds refers to the unit of the Georgina Basin but includes the equivalent Hooker Creek Beds of the Wiso Basin.

The Cambrian limestone does not outcrop in the map region. It is covered by Cretaceous deposits. These consist of lateritised claystone, claystone and some sandstone.

The most recent deposits are the Cenozoic alluvium, soil and sand which may only be several metres thick but masks most of the underlying Cretaceous deposits.

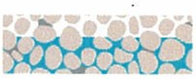
In terms of physiography most of the region is covered by tableland formed of Cretaceous sediments where creeks are poorly defined. To the north lies the upper Hodgson River drainage basin. The basin is formed on the volcanics and Bukalara Sandstone and is enclosed by scarps of Cretaceous rocks on three sides (Dunn, 1963). A physiographic map is provided as an inset on the water resources map.

6.3 Aquifer Type

An Aquifer is a body of rock that contains water and releases it in useable quantities. The rock contains water-filled spaces that are sufficiently connected to allow the water to flow through the rock. The spaces can develop from fractures, rock dissolution or occur naturally due to voids between the grains in the case of sandstone. Aquifers are classified according to the type of spaces.

When assessing the groundwater resource potential of a Rock formation, bore yields, springs, water quality, sinkholes and importantly rock type and the nature of the spaces in the rock is taken into account. The latter delineates aquifer type. The properties of the spaces determine how extensive an aquifer is, how easily water moves through it, and how much water can be stored in it. Aquifer type is related to rock type. There are three main aquifer types (Table 6.2).

Table 6.2 Aquifer types and their characteristics. (Adapted from Tickell, 2008)

Aquifer type	Description	Rock type that contains this aquifer type
Fractured 	Networks of fractures in the rock provide space for water to collect and move through. The degree of fracturing can vary greatly. Fractures are normally very small, less than a millimetre, but if there are enough of them an aquifer can exist. Where fracturing is extensive and interconnected throughout a formation a widespread aquifer results. Localised fracturing results in a localised aquifer which is usually not very productive.	All rock types. It is the main aquifer type for hard, impermeable rocks such as granite, schist, dolerite and silicified sandstone.
Fractured & Karstic 	This aquifer is created by the dissolution of the rock by water passing through it. It forms in carbonate rocks – limestone or dolomite. Over geological time frames these rocks are slightly soluble in water. As water moves through fractures, it gradually enlarges them as the rock is slowly dissolved. The process can form caverns but more commonly openings of millimetre to centimetre in scale.	Carbonate rocks – Limestone and dolomite
Sedimentary Porous rock 	This aquifer occurs in sands and sandstone. Pore spaces between the grains provide storage and a flow path for water. Not all sandstones have suffic-ient intergranular porosity to form an aquifer. Also over time, minerals may fill or partially fill the pore spaces hence the younger the sandstone the more likely it is to have its intergranular porosity intact.	Sands and sandstones

The effects of weathering can increase aquifer development and therefore has been included in the description of aquifer type. Weathering is the physical disintegration and chemical decomposition of rock. Physical weathering occurs from the alternate expansion and contraction due to temperature changes, and chemical weathering produces new minerals. Weathering can cause the development of new fractures or enhance existing fractures, resulting in better aquifers. Weathering can also cause the narrowing of fractures reducing aquifer development. The most productive aquifers commonly occur near the base of the weathered rock.

Weathering can be accelerated or enhanced by fracturing. When rock is fractured, open spaces develop in the rock mass, and water collects in the spaces. Aquifers can exist in rocks due to fracturing alone. Fracturing can occur in all rock types but the degree of fracturing can vary greatly. Faults are marked on geology maps but the degree of fracturing is not indicated. Fractures can be targeted for potential water supplies but specialist scientific advice should be sought.

Aquifers can consist of combinations of the main aquifer types.

6.3.1 Flow system description of aquifers

Aquifers can be described according to the distance groundwater moves through the aquifer, from where it enters the ground (recharge areas) to where it discharges back to the surface (discharge areas) (Figure 6.3). The distance it flows depends on the extent of the aquifer. It can vary from hundreds of kilometres to less than a kilometre. The scale of groundwater flow has been categorised by Coram and others (2000). These are termed groundwater flow systems (Table 6.3) and are used to describe the aquifers on the water resource map.

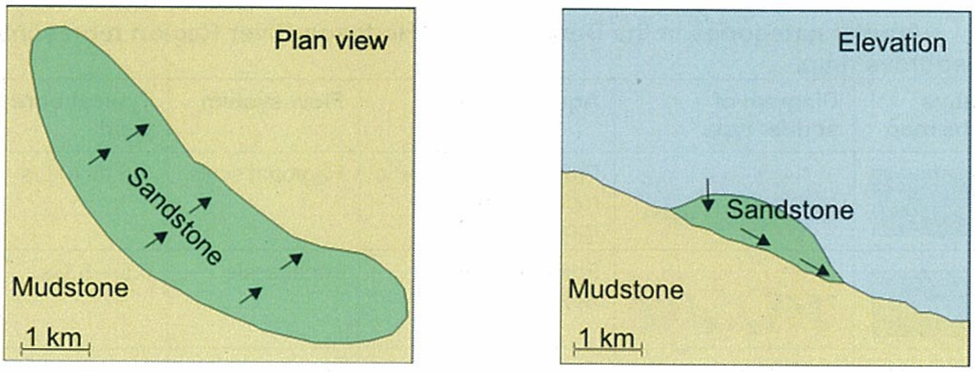


Figure 6.3 Flow path of water in a fractured rock aquifer. This is a local system.

Table 6.3 Aquifer flow systems (Adapted from Coram et al., 2000)

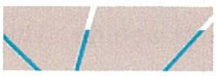
Groundwater flow system	Flow path distance of groundwater	Example
Local	< 5 km	Fractured rock aquifers in granite often have a short flow path because the aquifer is only as extensive as the group of fractures.
Intermediate	5 to 50 km	Carbonate rocks that extend for tens of kilometres can have longer flow paths as provided by the interconnected caverns.
Regional	> 50 km	In large sedimentary basins, like the Great Artesian Basin, the flow path is long because the sediments have been deposited over a very large area and remain connected. These aquifers may have high permeability.

The rate at which groundwater flows is usually very slow compared to river flows. It can vary from a few millimetres to several metres per year. Karstic aquifers are an exception where water can flow almost like a river through caverns when they exist. Depending on the size and type of an aquifer, it can take days to thousands of years for rainwater to complete its journey through an aquifer from when it infiltrates into the ground to when it discharges. The water we drink from some springs could be very old indeed.

6.3.2 Mapped aquifers / Groundwater resources

Groundwater resources are differentiated by aquifer category. In the Dunmarra and Hodgson River region three aquifer categories have been identified and drawn on the water resource map (Table 6.4). Each aquifer category has been determined by its aquifer type, flow system and the typical bore yield.

Table 6.4 Aquifer categories in the Dunmarra and Hodgson River Region represented on the water resources map.

Representative colour on the map	Diagram of aquifer type	Aquifer Type	Flow system	Typical bore yield
		Fractured and karstic rocks – carbonate rocks	Regional scale	0.5 to 10 L/s
		Fractured and weathered rocks	Local scale	0.5 – 5 L/s
		Fractured and weathered rocks with minor groundwater resources	Local scale	0 – 2 L/s

The occurrence and characteristics of each of these aquifers is detailed below. The extent of each of the aquifers has been determined by use of the geological maps and grouping together rock formations that contain the same aquifer type. Drilling information is used to confirm the interpretation of aquifer type and its extent. All water bores drilled in the Northern Territory are identified by a

Registration Number (RN) and these are plotted on the water resource map. Details of each bore are provided in Appendix A, D and E.

Fractured and Karstic Rocks – carbonate rocks

The Cambrian Limestone Aquifers

The Anthony Lagoon Beds and the Gum Ridge Formation comprise two Cambrian aged limestone aquifers. The Anthony Lagoon Beds consists of calcareous and dolomitic siltstone, fine grained sandstone, limestone and dolomite (Brown and Randall, 1969). The formation occurs in the south and south east of the map (see Figure 6.4) reaching a maximum recorded thickness of 210m in investigation bore RN036471, which was drilled for the project in the south of Hayfield Station. A detailed log of this bore is provided in Appendix B.

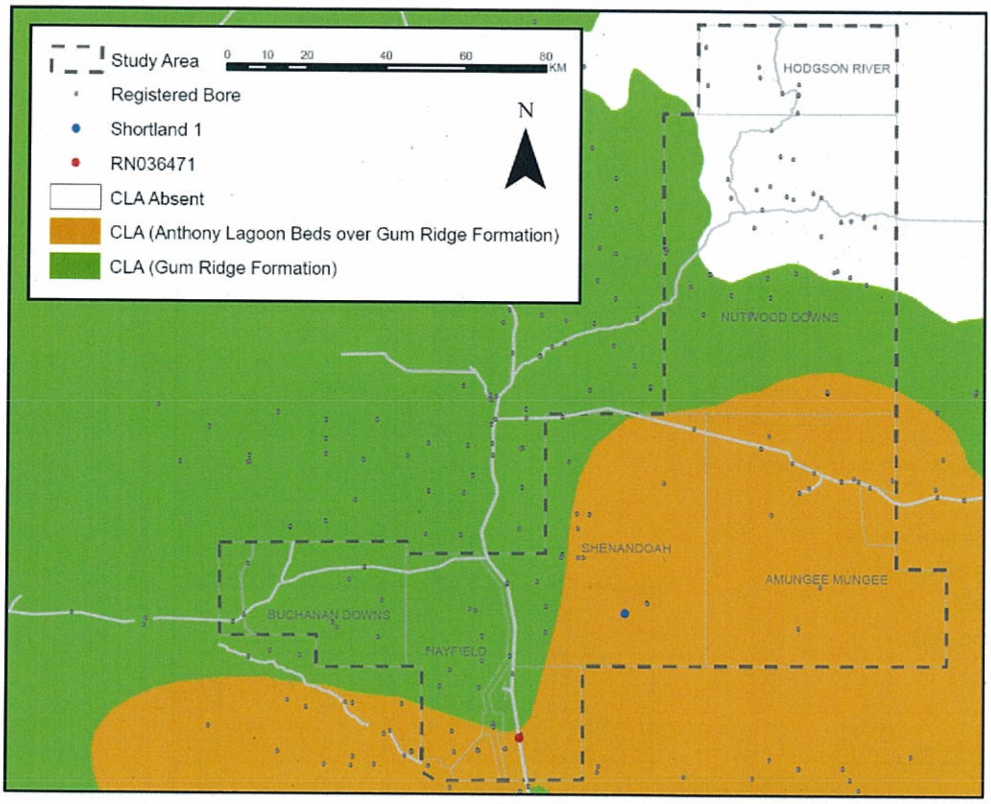


Figure 6.4 Extent of the Cambrian limestone
CLA = Cambrian limestone aquifer

The Gum Ridge Formation consists of limestone, dolomitic limestone, siltstone and chert (Kruse, 1998). The formation is a key regional aquifer in the Georgina Basin. The edge of the basin bisects Nutwood Downs Station and the formation is absent in the north of the station and on Hodgson River Station. The Gum Ridge Formation becomes thicker to the south reaching a maximum recorded thickness of 230m in oil exploration bore Shortland No. 1, which was drilled in the south of Shenandoah Station. On Shenandoah and Amungee Mungee Stations the Gum Ridge Formation underlies the Anthony Lagoon Beds.

The Cambrian limestone aquifers do not outcrop in Dunmarra-Hodgson River area and to access the aquifers you need to drill through Quaternary and Tertiary alluvial deposits as well as siltstone and sandstone of the Cretaceous Mullaman Beds. These overlying formations range in thickness from less than 25m in the north of the map to over 125m in the south. Figure 6.5 provides an indication of the drilling depth to the top of the Cambrian limestone aquifers. To tap the water resource it is necessary to drill into one of the aquifers until groundwater is intersected; this may involve drilling tens of metres below the physical top of the formation. The Gum Ridge Formation overlies the Antrim Plateau Volcanics (also locally referred to as the Nutwood Volcanics) over much of the mapped area. An inset is provided on the map showing the elevation (in AHD[3]) of the top of the volcanics. Another inset on the map shows ground level also in AHD. The difference between the two levels provides a guide for estimating the maximum depth of Cambrian limestone from ground level. Combining this with the information provided by Figure 6.5 (also provided on the map) allows the thickness of the Cambrian limestone to be estimated.

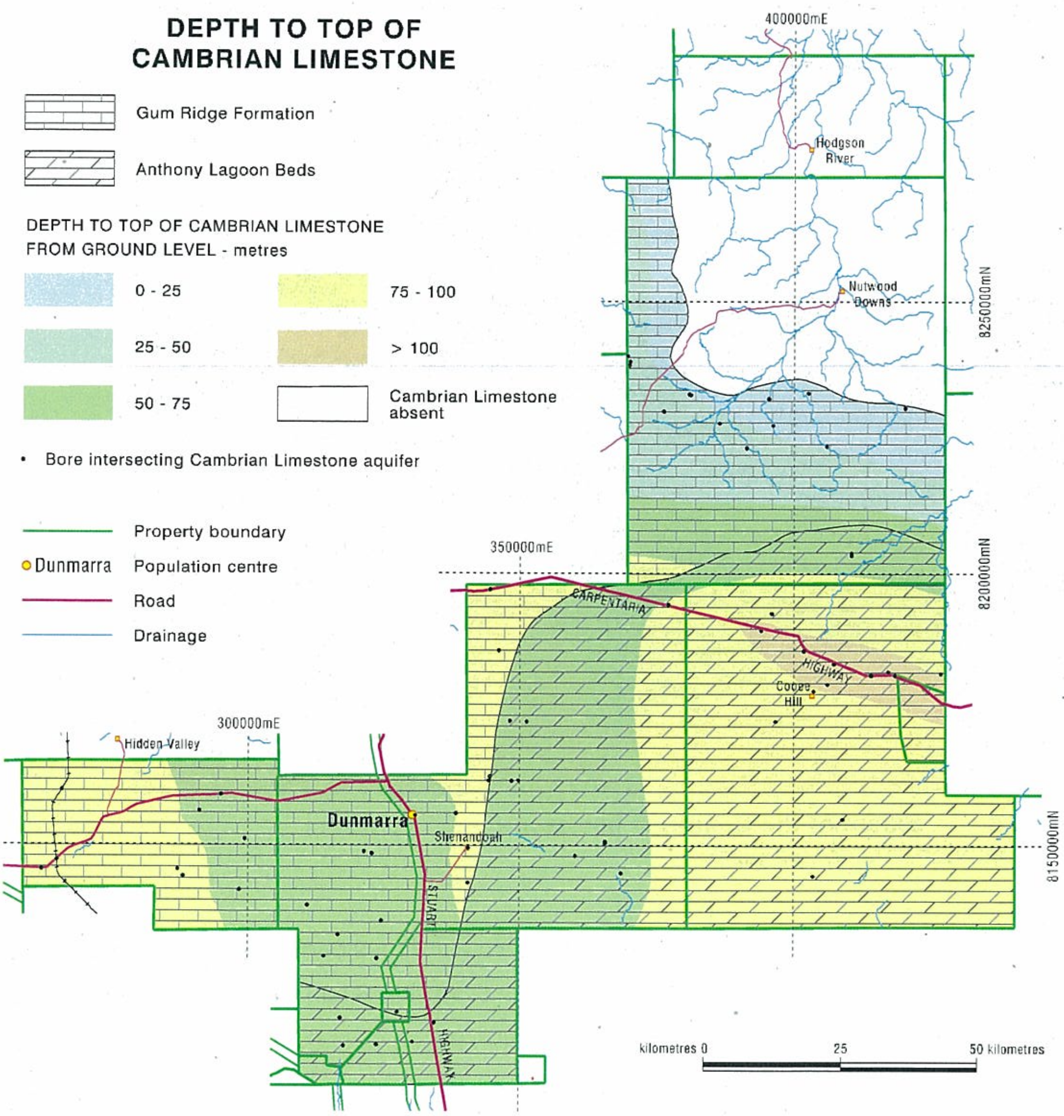


Figure 6.5 Depth to the top of the Cambrian limestone

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[3] AHD = Australian Height Datum where '0' is mean sea level.

The Cambrian limestone aquifers are the primary water resource in the Dunmarra-Hodgson River region except in the northeast where the Georgina Basin pinches out and the aquifers are absent. Within the map area there are 70 bores constructed in the Cambrian limestone aquifers, this represents around 70% of all successful bores drilled in the region (see Table 6.5). Recorded airlift yields for the aquifers range between 0.3 L/s and 25 L/s. The average yield of 3.3 L/s reflects the fact the majority of bores tapping these aquifers have been drilled for stock and domestic use. Commonly the yield requirement for stock bores is small and as such bores only target the top section of the aquifers. Bore RN036471 was drilled as an investigation bore for the Gulf Study project. This bore penetrates the entire thickness of the Anthony Lagoon Beds and produced an airlift estimate in excess of 25 L/s. The result suggests that bores which fully penetrate either of these aquifers and are well constructed, may achieve significantly higher yields than existing bores.

Table 6.5 Dunmarra-Hodgson River bore yields

Aquifer Screened	Number of Bores	Yield Range (L/s)	Average Yield (L/s)
Cambrian limestone aquifers	70	0.3 - 25	3.3
Bukalara Sandstone	22	0.3 – 5	2.5
Nutwood Volcanics	2	Insufficient data	Insufficient data
Mullaman Beds	2	Insufficient data	Insufficient data
Undifferentiated Proterozoic	2	Insufficient data	Insufficient data
Unsuccessful/No data	*29*	*NA*	*NA*

The depth to groundwater in the Cambrian limestone aquifers ranges from 27m below ground level along the northern edge of Basin, to over 125m below ground level along the Carpentaria Highway on Amungee Mungee Station. A generalised depth to watertable map is provided in Figure 6.6 and on the map. There are no known monitoring bores in the Cambrian limestone aquifers in the Dunmarra-Hodgson River region. Consequently little is known about groundwater level trends and flow paths within the aquifers. Limited water level data collected from bores at the time of drilling suggests groundwater in the Cambrian limestone aquifers flow in a broad northwest direction.

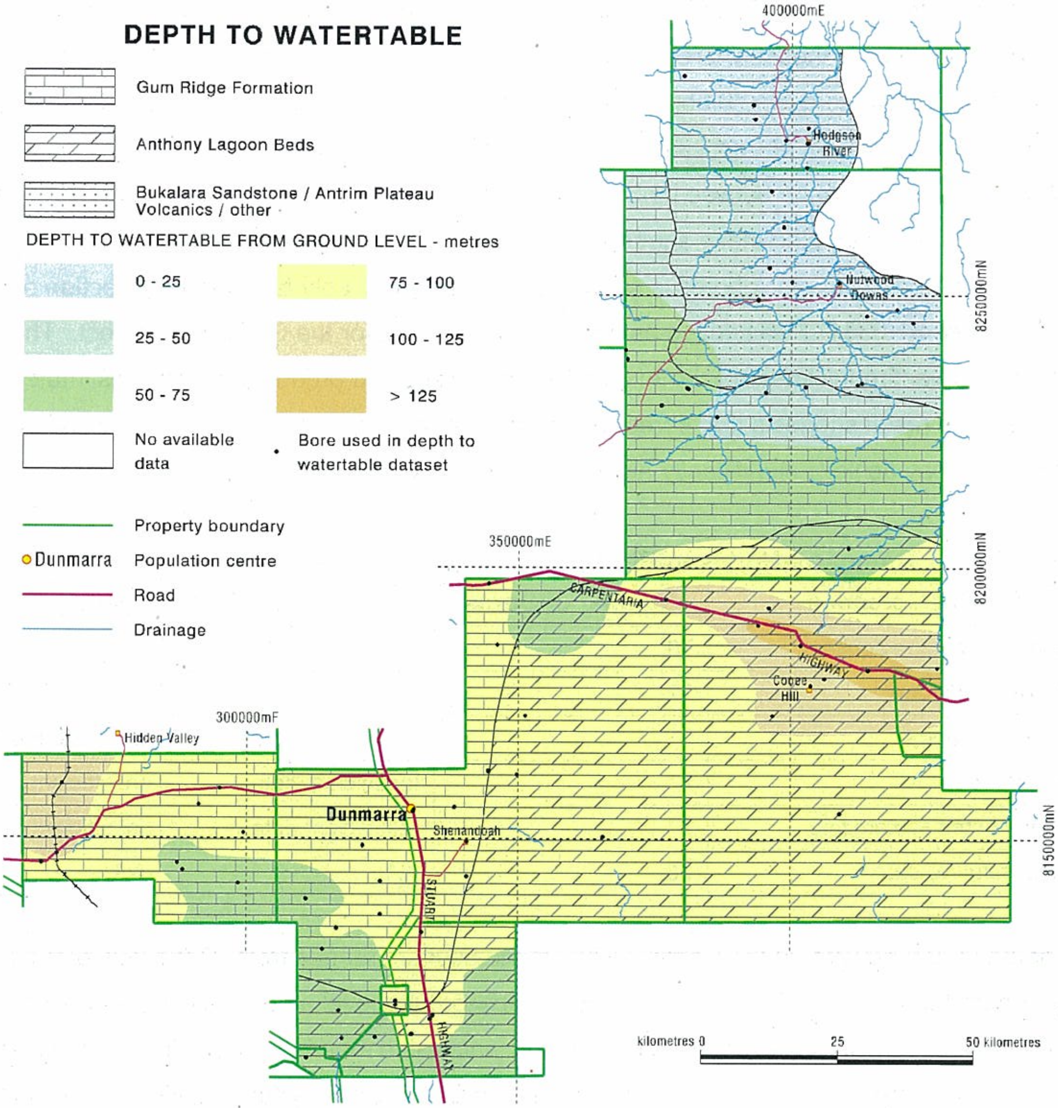


Figure 6.6 **Depth to watertable**

Fractured and weathered rocks

Bukalara Sandstone

The Bukalara Sandstone aquifer occurs in the north of Nutwood Downs Station and on Hodgson River Station. The formation consists of red to white quartz sandstone with minor interbedded shale (Dunn, 1963). Jointing within the sandstone is likely to increase the potential yield of the aquifer. The Bukalara Sandstone outcrops in a thin band to the north of the Nutwood Downs Homestead. To the west and south of the homestead the aquifer is capped by basalts of the Nutwood Downs Volcanics. The thickness of the basalt cover varies from 10's of metres up to 140 metres in bore RN034181. The basalt acts as a confining layer and it is necessary to drill through this formation to access groundwater in the underlying sandstone. In two bores (RN023164, RN009378) minor groundwater supplies have been encountered in the fractured basalt of the Nutwood Downs Volcanics. However, the majority of bores in the area target the underlying Bukalara Sandstone which suggests the groundwater resource in the Nutwood Downs Volcanics is marginal at best.

The Bukalara Sandstone reaches a maximum recorded thickness of 289m in oil exploration bore Mcmanus 1, which was drilled on Maryvale station 15km west of the Dunmarra-Hodgson River region. Within the map area there are 22 successful bores constructed in the Bukalara Sandstone aquifer. Bore yields estimated from airlifting typically range between 0.3 and 5L/s with an average yield of 2.5L/s. The depth to water in the aquifer ranges from 3 to 34 metres below ground level (see Figure 6.6). Groundwater flows in a northerly direction within the Bukalara Sandstone aquifer.

Minor in extent are the Hodgson Sandstone and Arnold Sandstone of the Roper Group. These sandstones have similar characteristics. They largely lie in the north-east of the map region. They have not been extensively drilled in the region but yields at the lower end of the range (<3 L/s) are anticipated.

Fractured and weathered rocks with minor groundwater resources

Minor groundwater supplies may be encountered in the fractured and weathered Proterozoic siltstones, mudstones and sandstones of the Roper Group in the north-east of Nutwood Downs Station and eastern and western Hodgson River Station. These rocks are often only sparsely fractured and therefore contain only low yielding aquifers. Low yields (<2 L/s) should be expected. Similarly groundwater resources in Cretaceous deposits are considered marginal and where they overlie the Cambrian limestone the latter is targeted.

6.3.3 Other groundwater supplies

Alluvial deposits can also provide minor groundwater supplies. These unconsolidated sediments belong to the sedimentary porous rock aquifer type (Table 6.2) and are associated with the deposition of sediment along stream and river courses. They are limited in extent and are not shown on the map. Bores generally yield less than 0.5 L/s. At present there are no registered bores in the map area accessing shallow alluvial aquifers.

6.4 Groundwater Quality

Groundwater quality is affected by evapotranspiration of rainfall and rock type.

Rainwater contains salts. As rainwater moves down through the soil to the watertable evapotranspiration concentrates the salts. Salts are made up of ions. For example table salt (Sodium Chloride) is made up of the ions Sodium and Chloride. Common ions used to describe water quality are listed in Appendix E. If recharge is low then the salts can become so concentrated that the water becomes unsuitable for human consumption. Low recharge can be due to low rainfall but it can also be related to rock type. Mudstones for example would have low recharge because the small particle size of the rock allows little water through.

Rock type affects water quality because, as water moves through them, it picks up (dissolves) salts from the surrounding rock. This process is particularly evident in limestone and dolomite because they contain high amounts of calcium or magnesium carbonate which dissolve in acidic conditions (Plate 6.1) and our rainfall is naturally acidic. When these rocks dissolve, calcium, magnesium and bicarbonate ions are released into the water. Hence groundwater rich in these ions has most likely come from a limestone or dolomite Formation.

Plate 6.1 A drop of acid dissolving limestone as shown by the fizz. This is a common field test for carbonate rocks.

6.4.1 Water quality measurements

In order to describe the quality of water and its suitability for drinking or other use, a number of parameters can be measured in the field and in the laboratory. One of these parameters is Total Dissolved Solids (TDS) which is a measure of the saltiness of the water. It is usually described in terms of the number of milligrams of salt in a litre of water (mg/L).

The Australian Drinking Water Guidelines (ADWG, 2004) define good quality drinking water for human consumption from the perspective of health and aesthetics. The guidelines state that good drinking water has a TDS of less than 500 mg/L, and that a TDS of 500 – 800 mg/L is fair. A TDS of greater than 1000 mg/L is considered unacceptable. High TDS may be associated with excessive scaling and unsatisfactory taste. A simple way of estimating TDS in the field is by measuring the water's electrical conductivity (EC). Salt present in the water will make it more conductive for an electrical current, which can be easily measured with a small field probe (Plate 6.2). EC is measured in microSeimens per centimetre, µS/cm. TDS is approximately equal to 0.6 x EC.

Plate 6.2 Ursula measuring the EC of a creek.

Water can also be described as being 'hard' or 'soft'. 'Hard' water requires more soap to produce suds than 'soft' water, and is generally associated with groundwater occurring in limestone and dolomite aquifers. These aquifers contain calcium or magnesium rich waters. Water having more than 150 mg/L calcium carbonate can deposit scale in pipes and water heaters under favourable conditions.

Another parameter which can be easily measured in the field, and give an immediate indication of water quality and suitability is pH. pH is a measure of the hydrogen ion concentration. Water is said to be either acidic or alkaline, depending on the relative concentration of hydrogen ions. A pH of 7 indicates neutrality, a pH of less than 7 indicates an acidic water, and a pH of greater than 7 indicates an alkaline water (Table 6.6). A low pH can be caused by high levels of dissolved carbon dioxide. Acidic water is corrosive to metal bore casing and pipes, but is still suitable for consumption if plastic or PVC bore casing and pipes are used to distribute the water. Alternatively, the water can be treated by aeration, which allows the dissolved carbon dioxide to be released to the atmosphere, causing the pH to increase. Alkaline water is generally associated with limestone or dolomite aquifers, and is a good indicator of the aquifer rock type. High alkaline waters can also be treated to lower pH. It should be noted that pH measurements taken from airlifted water during the drilling process may not give a true indication of the pH.

Table 6.6 pH and water quality characteristics observed in the map region.

Acidic	Neutral	Alkaline
pH < 7 Often due to high levels of dissolved carbon dioxide	pH = 7	Ph > 7 Can be due to high carbonate content sourced from dolomite or limestone
Generally EC < 150 μS/cm indicating low mineral content in the water. The surrounding rocks may be inert or recharge may be high.		Generally EC > 300 μS/cm indicating that the water may contain dissolved minerals from the surrounding rock.

Measurement of pH in the field is important, as during sampling, storage and transportation to a laboratory, there may be changes in pH due to chemical reactions. Field measurement is easy, and generally done by using a small probe which can give excellent results if regularly calibrated.

Besides undertaking field measurements of water quality parameters, water samples were also taken from a number of springs, creeks and bores prior to and during this project. These samples were then analysed in a laboratory where the quantity of common ions in the water was determined. These results are detailed in Appendix E. The water quality could then be characterised for an aquifer or a stream.

6.4.2 Water Quality and Aquifer Type

Following is a basic description of water quality for each of the aquifer categories denoted on the water resource map.

Fractured and Karstic Rocks – carbonate rocks

Cambrian Limestone Aquifers

In the map area, the Cambrian limestone aquifers have an average TDS of 770 mg/L and a range between 93 and 1640 mg/L. The pH of the aquifer is sub-neutral varying between 6.2 and 8.7, the normal pH range in groundwater is 6 to 8.5 (Hem, 1985). A breakdown of groundwater TDS in bores screening the Cambrian limestone aquifers, according to Australian drinking water standards (ADWG, 2004), is provided in Figure 6.7. 50% of the constructed bores report groundwater of good to fair quality. Spatially, groundwater quality deteriorates west of the Stuart Highway, an area that coincides with the bedrock high separating the Georgina and Wiso basins. In this area the groundwater resource is very marginal as a drinking supply. All recorded groundwater samples in the Cambrian limestone aquifers are of suitable quality for stock watering. Due to the carbonate aquifer type groundwater is typically very hard with an average value of 376 mg/L ($CaCO_3$). Bore water is likely to deposit some scale in pipes and hot water systems. The groundwater also has elevated iron concentrations (average 3.0 mg/L), which may lead to staining and fouling of pipes and appliances.

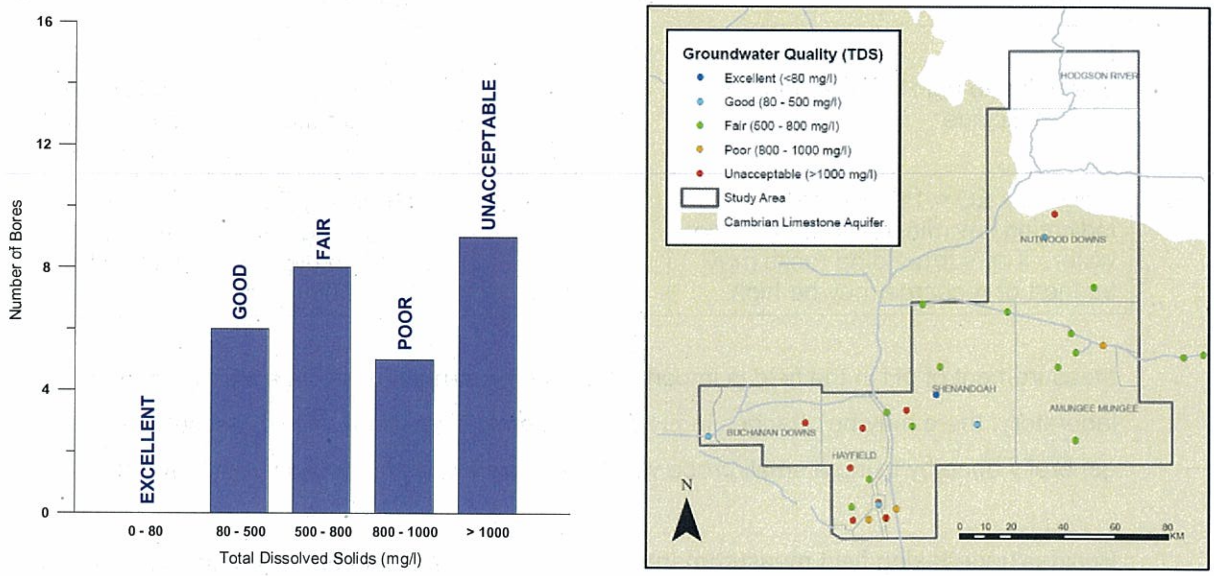


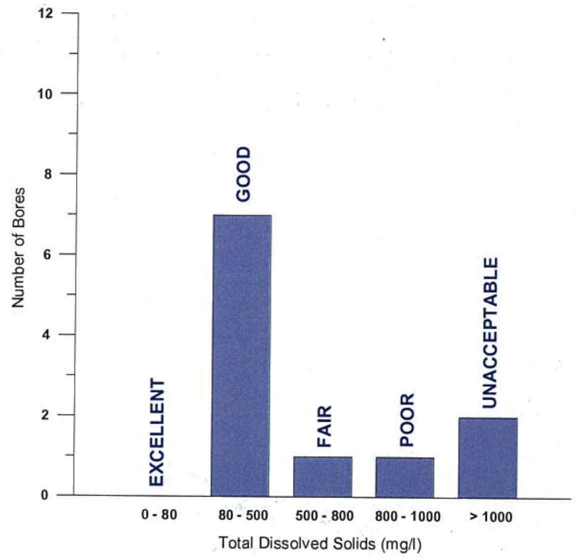
Figure 6.7 Breakdown of groundwater quality in bores screening the Cambrian limestone aquifers according to drinking water standards (ADWG, 2004) and the spatial pattern of groundwater TDS in registered bores across the Cambrian limestone aquifers.

Fractured and weathered rocks

Bukalara Sandstone

Groundwater in the Bukalara Sandstone aquifer has an average TDS of 550 mg/L and a range from 130 to 1510 mg/L. A breakdown of groundwater TDS in bores screening the Bukalara Sandstone aquifer according to Australian drinking water standards (ADWG, 2004) is provided in Figure 6.8.

Around 60% of Bukalara Sandstone bores have a TDS that falls in the good drinking water category. However, the aquifer has a low level of development with only 16 registered bores and consequently spatial variation in groundwater quality within the aquifer is not well understood. Groundwater is neutral with a pH range of 6.3 to 7.9. Scaling, staining and fouling may be encountered with groundwater use due to elevated iron concentrations (average 1.7 mg/L) and because the groundwater is typically hard (average 221 mg/L $CaC0_3$).



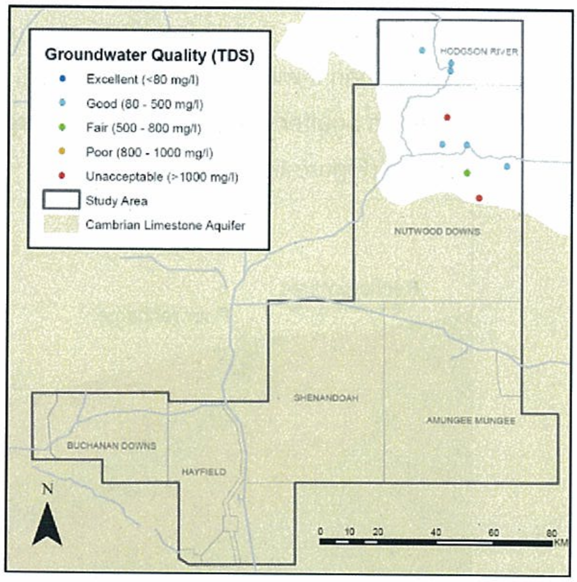


Figure 6.8 Breakdown of groundwater quality in bores screening the Bukalara Sandstone aquifer according to drinking water standards (ADWG, 2004) and the spatial pattern of groundwater TDS in registered bores in the Bukalara Sandstone Aquifer.

Fractured and weathered rocks with minor groundwater resources

Generally, quality in these minor fractured and weathered aquifers has a very wide variation and it is not unusual for the TDS to exceed the guideline value for drinking water, with rock type and poor recharge being the likely causes.

6.5 Recharge

Recharge is where water is added to an aquifer. Recharge can be observed by monitoring water levels in bores. It is important to carefully manage areas where recharge occurs to ensure groundwater quality is maintained.

Recharge is where water is added to an aquifer (Figure 6.1). Recharge amounts vary with rainfall, soil and geology. It occurs through three main mechanisms; diffuse, point source and stream bed. Diffuse recharge is the widespread downward seepage of rainwater, point source recharge occurs through an opening in the ground such as a sinkhole allowing direct drainage to the aquifer, and stream bed recharge is where water drains from a stream to an aquifer (the water level of the aquifer must be lower than river level for this to occur).

Recharge is affected by geology or rock type and soil type. The amount of water that reaches an aquifer is dependent on the rock types or soils that overly the aquifer as well as the rocks that make up the aquifer. Water moves through some rocks and soils better than others, that is, they have a better permeability. Permeability is affected by the size and shape of the voids in the rock and how well the voids are interconnected. A coarse sand or a limestone, for instance, has a high permeability whereas a mudstone or a poorly fractured granite has a low permeability. If a sand is overlain by a mudstone or clay, then it will be poorly recharged, but if it is unconfined it will be better recharged (Figure 6.9). When an aquifer is confined the recharge area can be restricted to the area where the rock is in outcrop (Figure 6.9).

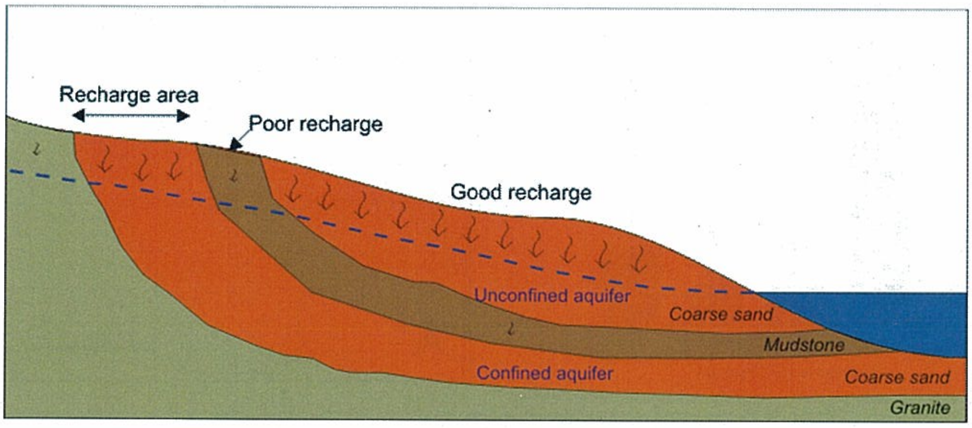


Figure 6.9 Recharge to a confined and unconfined aquifer.

High rainfall usually results in better recharge. Recharge is indicated by the rise of groundwater levels and can be observed in bores which are monitored. Currently there are no bores being monitored in the map region however we can gain an insight of the variation in recharge to the Cambrian limestone aquifers in the Dunmarra region from bores located further afield, west and north of the map region, but within the aquifers. The data from these bores is presented in Figure 6.10.

At RN029013 and RN029012 (Figure 6.10) the Gum Ridge Formation is located under Cretaceous cover and there is little recharge as observed by the low variation in water level. This is the type of response to rainfall we would expect to see in the map region as the aquifer similarly lies beneath Cretaceous sediments. Where the cover is thin recharge is more likely, such as the central region of Nutwood Downs Station where the Cambrian limestone is closest to the surface (ie between 0 – 25 m below ground level, Figure 6.5). Where the aquifer is in outcrop better recharge is enabled and a more dynamic variation in water level is observed such as at RN034039.

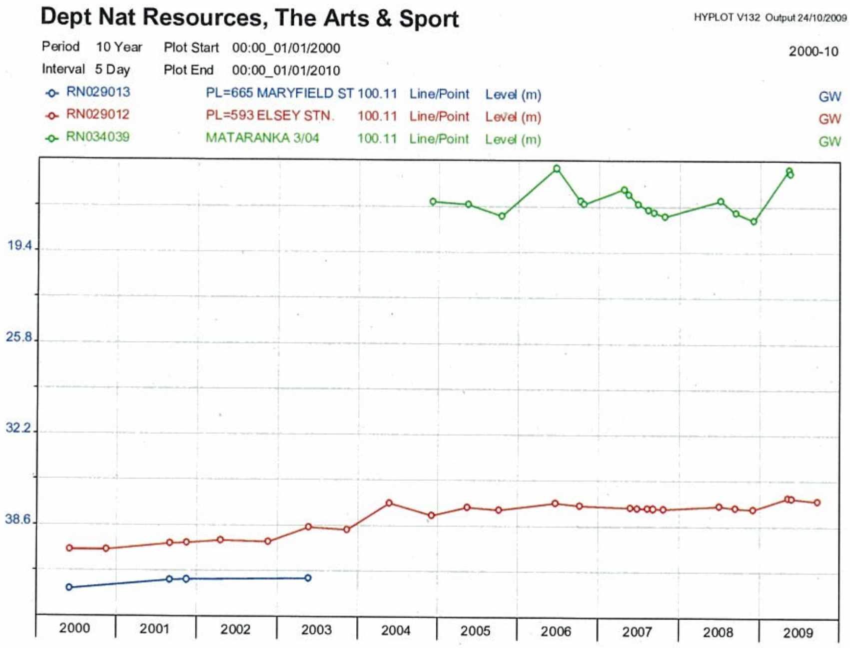


Figure 6.10 Water levels in bores within the Cambrian limestone aquifers.
(Not within the map region)

Recharge areas should be managed to ensure water quality is maintained. For example, sewage works should no be located over recharge areas. Recharge is often described as the amount of rainfall that has entered an aquifer in mm/year or by the rise in water level in an aquifer in metres. Up to 20% of annual rainfall results in groundwater recharge.

The sustainable yield of an aquifer can be considered as that amount that can be extracted from an aquifer without adversely affecting the environment and reducing the average groundwater level in that aquifer. In other words the extraction rate should be less than the average recharge rate.

As part of the Gulf Water Study the Gum Ridge Formation and its lateral equivalents were modelled by Knapton using the computer based Feflow numerical groundwater model and a report is available (see Knapton, 2009). The aquifer discharges to the Roper River at Mataranka providing baseflow to the river thereby maintaining ecosystems downstream. There is strong demand for water from this aquifer for agriculture and hence water allocation planning for the aquifer has commenced at Mataranka. The model will feed into this process and provide a guide to sustainable extraction limits of the aquifer.

6.6 Groundwater discharge and dependent ecosystems

One way groundwater discharges is through springs. Springs and seeps are marked on the water resource map. Localised springs are where groundwater discharges from one point but groundwater can also discharge as diffuse flow along a river bed. Diffuse or streambed seepage is where a stream cuts through an aquifer allowing water to drain into the stream. The area of drainage forms the discharge zone, which is marked by a gradual downstream increase in river flow. Another less obvious way in which groundwater discharges is through evapotranspiration. Plants can tap into groundwater when it is shallow enough and similarly groundwater can be directly evaporated through the soil when it is within two metres of the surface.

Springs occur where the watertable is at or above the ground surface. They can be permanent (perennial) or periodic (ephemeral) due to fluctuations in the local watertable.

There are no springs discharging from the extensive Cambrian limestone aquifers in the map region as the watertable within this aquifer lies at least 25 m below ground level. Springs however do discharge from this aquifer further north (around Mataranka), outside of this map region. These springs include the iconic Mataranka hot springs.

6.6.1 Types of springs

Springs are located on Hodgson River Station and Nutwood Downs Station. The likely spring types on these stations are outlined below.

Depression Springs

This type of spring results when the watertable is intersected by a low point (a depression) in the landscape such as a valley or escarpment, allowing drainage to occur from the surrounding rock. (Figure 6.11) Sometimes the low point in the landscape is resultant of a fracture or fault and the aquifer can be localised to that feature. Some springs can be temporary features occurring only when the watertable reaches the surface after periods of good rainfall.

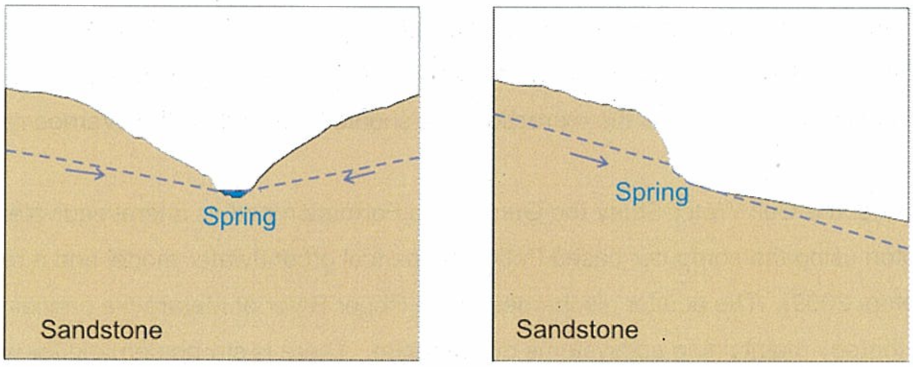


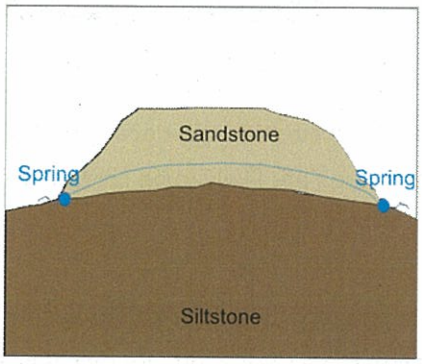
Figure 6.11 a & b **Depression spring in a valley and at an escarpment**

Contact Spring

This type of spring arises when a more permeable rock such as sandstone, lies above a less permeable rock such as siltstone (Figure 6.12a). Water stored in the upper layer seeps out at the contact between the two rock types because it is unable to penetrate into the lower layer. Often there is a zone of seepage or swampy area at the contact. Seepage along the contact can eventually coalesce to form a creek. These springs are often seen at the base of escarpments.

Another type of contact spring can occur where a less permeable rock overlies and confines a more permeable rock (Figure 6.12b). Water stored in the lower layer seeps out at the surface where it is no longer confined.

Often at the contact between two rock types there can be enhanced weathering in the rocks enabling aquifer development.



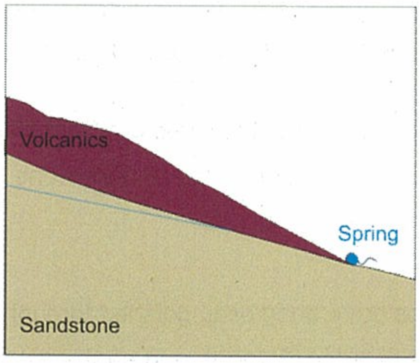


Figure 6.12 a&b **Contact spring where a more permeable rock overlies a less permeable rock and visa versa.**

Fault Spring

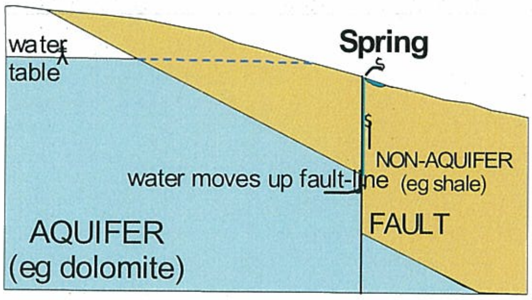


Figure 6.13 **Spring discharge from a fault.**

This type of spring occurs when a fracture or fault provides a pathway to allow groundwater to rise to the surface, in areas where it is normally confined beneath a low permeability rock. Sometimes hot water emerges from these springs because they are sourced from some depth below the surface.

6.6.2 Occurrence of springs

The spring at Nutwood Downs Station homestead and Cambell Spring on Hodgson Downs Station are likely fault springs as the geology map clearly shows faults at the spring locations. The Nutwood Downs Spring is surrounded by water loving vegetation such as palms and paperbarks (Plate 6.3). This is considered a groundwater dependent ecosystem and it provides a refuge to wildlife.

Plate 6.3 a & b Spring at Nutwood Downs Station.

Kempsey Spring and Crawford Spring lie at the contact between the overlying Antrim Plateau Volcanics and the Bukalara Sandstone. These springs are likely to be contact springs of the type shown in Figure 6.12b.

Seeps have been distinguished through satellite imagery as areas marked by lush vegetation. They are located in the north and north-east of Hodgson River station but are only few in number. These are likely to be depression or contact springs of the type shown in Figure 6.11 and 6.12. Some of the seeps are also associated with faults. Faults or fractures provide added permeability to rocks. At times the groundwater in sandstone escarpments does not break out in the form of a spring but comes close to the surface. These areas are often also marked with lusher vegetation as tree roots find their way to the watertable. The vegetation associated with springs can effectively be considered groundwater dependent.

7 SURFACE WATER

Surface water occurs as rivers, springs, lakes and billabongs and can be characterised into two main sources: directly from rainfall and rainfall runoff; or from groundwater discharge which provides baseflow to many rivers in the Top End (Figure 7.1).

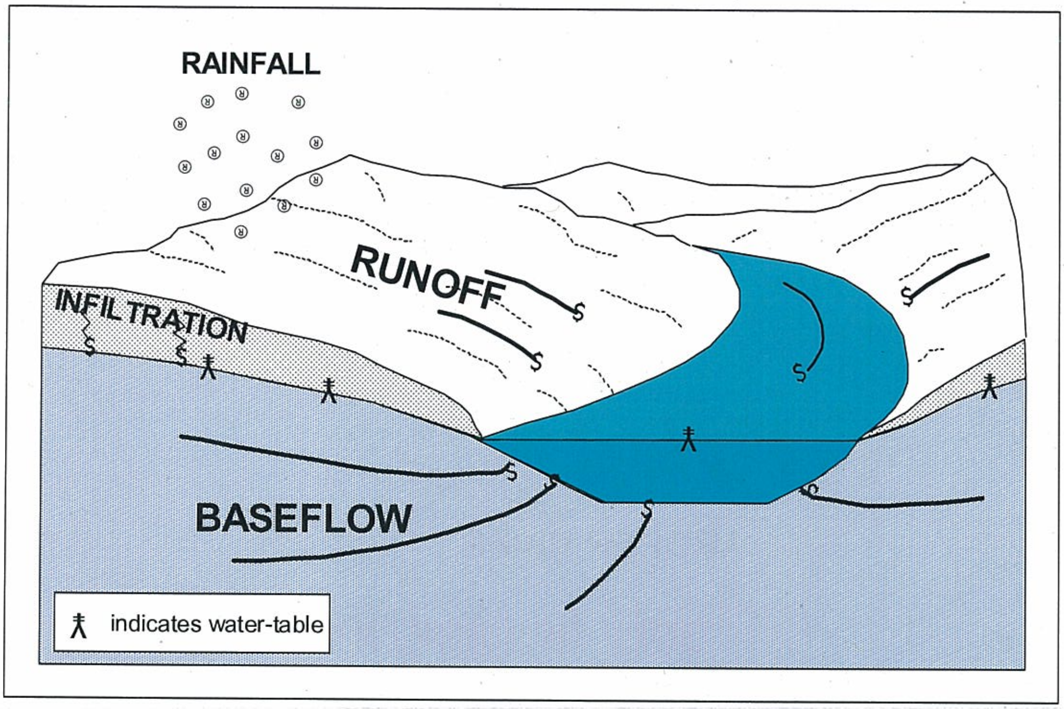


Figure 7.1 Runoff and Baseflow Components of Surface Water

When examining surface water occurrence it is important to distinguish between these two sources. Surface water derived from wet season rainfall and runoff will only persist if storage is high enough to last through the Dry season. It is the baseflow component that keeps rivers and creeks flowing through the long Dry season.

In this map region there are no permanent flowing rivers because there is insufficient baseflow. Essentially the rivers provide drainage of wet season rainfall-runoff. Only isolated permanent waterholes occur in deeper sections of the Arnold and Hodgson Rivers on Hodgson River Station. The Arnold River has numerous large waterholes, the largest of which is Minimere. Some of these waterholes could be targeted for domestic or stock water supplies.

In the Wet season, river flows increase due to rainfall runoff. The increase in flow at a point along the river is dependent upon the rain that has fallen in the catchment upstream from that point. For the same amount of rainfall, larger catchments have larger flows.

7.1 How surface water sites are recorded

All NRETAS surface water sites have a unique 'gauge site' (G) number and name eg. G9030252 Arnold River at 4 km u/s Minimere lagoon. The first three digits of the (G) number refer to the basin (catchment) in which the site is located and the following digits identify the site. Figure 7.2 shows the two basins in the map region, 903 Roper River and 028 Wiso. The Roper River basin lies in the north and the Wiso basin in the south. The divide between these two basins is shown on the map.

A listing of all the NRETAS surface water sites within the mapped area is provided in Appendix F. All these sites lie within the Roper River catchment '903'. At only one site has flow been measured. These sites largely record water quality and this data is provided in Appendix G.

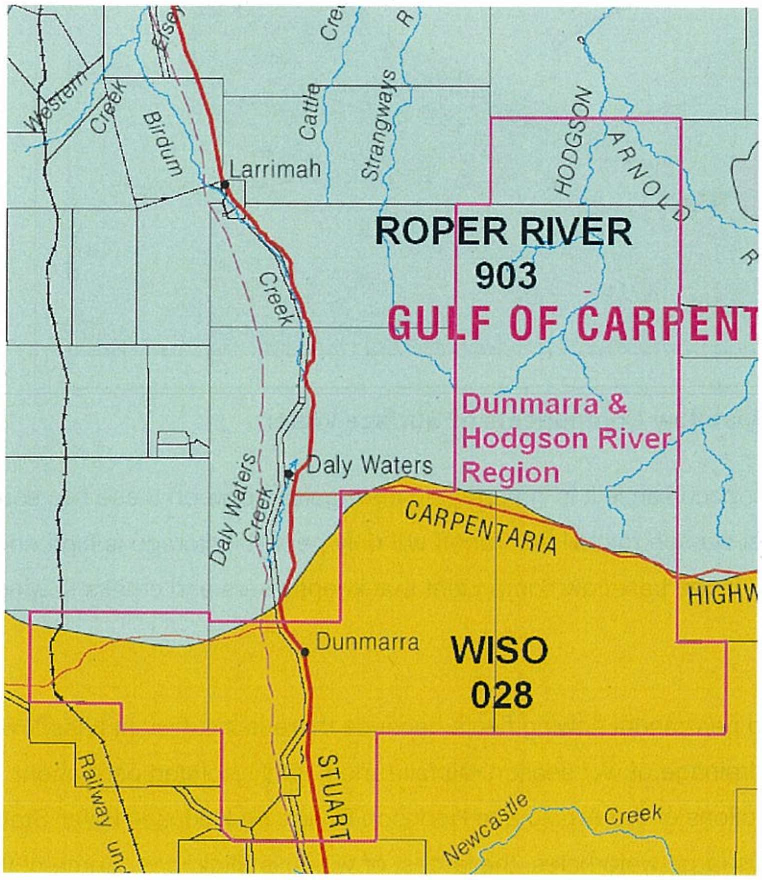


Figure 7.2 Basins in the Dunmarra and Hodgson River Region
(Excerpt from DIPE, 2002)

On the Water Resources maps for the Gulf region flows along rivers and creeks are plotted according to the minimum flow reflecting the environment at its driest. However over the Dunmarra Hodgson River region most rivers dry up. Only in the Hodgson and Arnold Rivers will isolated waterholes remain. The larger waterholes have been marked on the map.

8. WATER RESOURCE DATA AND AVAILABILITY

A listing of departmental water resource reports pertaining to this region is provided in Appendix C.

The Water Resource Map that accompanies this report was produced by NRETAS. It can be reprinted at any time and made available to interested parties.

All products produced for the Gulf Water Study are available in digital format on DVD. The DVD titled 'The Gulf Water Study' contains the following products:

- The five water resource maps covering the Gulf region
- This report and the reports for the other regions of the study
- Posters pertaining to the study area
- A GIS which uses the program Arc Explorer
- A spatial photographic and video database

The DVD is available through the Natural Resources Division of NRETAS.

All detailed information on surface water sites is kept on the NRETAS 'Hydstra' database. Requests for such data can be made to: Spatial Data and Mapping Branch, NRETAS Phone (08) 8999446, Email: DataRequests.NRETA@nt.gov.au

All bore reports are available through the internet site www.nt.gov.au/nretamaps. These are regularly updated.

10. GLOSSARY

Airlift Yield: The rate at which water is extracted from a bore using compressed air downhole.

Aquifer: A body of rock which is sufficiently permeable to conduct groundwater and to yield useable quantities of groundwater to bores and springs

Baseflow: The groundwater contribution to a stream. Baseflow often maintains the flow in a stream over the Dry season.

Catchment: Area in which rainfall collects to form the flow in a river.

Confined aquifer: A confined aquifer occurs where an aquifer is overlain by a confining bed. The confining bed prevents upward movement of the groundwater. Such aquifers are usually completely saturated with water which is commonly under pressure. Therefore when a bore intersects the aquifer, water rises up the bore. If the pressure is sufficient to drive the groundwater above the ground level, the bore is called artesian.

Carbonate rock: A rock such as limestone or dolomite, consisting largely of the carbonate minerals; calcium carbonate or calcium magnesium carbonate.

Consolidate: Any process whereby soft or loose earth materials become firm, for example the cementation of sand or the compaction of mud.

Dolomite: A sedimentary rock composed mainly of the mineral dolomite (calcium magnesium carbonate)

Electrical conductivity, EC: The measure of the ability of water to conduct electrical current. The magnitude is directly related to the dissolved mineral content of the water. EC is measured in microseimens per centimetre, μS/cm.

Ephemeral: A creek or river that dries up in the dry season.

Evaporation: The process whereby liquid water turns to vapour. It accounts for the movement of water to the air from sources such as the soil, canopy interception, and waterbodies.

Evapotranspiration: The sum of evaporation and plant transpiration from the Earth's surface to the atmosphere. Transpiration accounts for the loss of water from plants as vapour through its leaves.

Fractured: A fractured rock is one that is broken by joints, cracks or faults.

Geology: Science of earth's composition, crust, rocks, origin, structures, historical changes and processes.

Geographic Information System (GIS): A computer system that captures, stores, analyses, manages and presents data that is linked to location. Data can be viewed and accessed using a computerised map.

Geophysics: The use of specialised surveys to give an indication of underlying rock type. Techniques such as magnetics, gravity, electro-magnetics, and seismics can be used on the earth's surface in order to indicate geology.

Groundwater: Water beneath the surface of the earth that is in the saturated zone.

Groundwater dependent ecosystems: A community of plants and animals that rely partially or completely on groundwater for its existence.

Groundwater Discharge: The release of groundwater to the surface by seepage, evaporation or transpiration (from plants).

Hardness: A measurement of the level of calcium carbonate in water.

Impermeable: An impermeable soil, rock or sediment is that in which fluid (water) is unable to pass through.

Karst: A term describing typical geologic/topographic attributes of limestone or dolomite resulting from mineral solution such as caves and sinkholes.

Monitoring/Observation bore: A bore used for measuring groundwater levels.

Perennial: A stream, lake or waterhole which retains water throughout the year.

Perennial flow: Flow that is retained throughout the year.

Permeability/Permeable: The capability of sediments and rocks to allow water to move through them.

pH: A measure of acidity (low pH) or alkalinity (high pH). A pH of 7 indicates neutrality whereas lower pH levels indicate acidity.

Porosity: The total amount of pore space in a soil or rock.

Recharge: Addition of water to an aquifer to become groundwater.

Runoff: Rainwater that leaves an area as surface flow.

Sandstone: A sedimentary rock composed of sand grains cemented together.

Spring: Outflow points for groundwater where the watertable is near or above the ground surface.

Siltstone: A sedimentary rock composed of silt sized particles.

Standing Water Level: The level below ground surface, to which groundwater rises in a bore.

Surface Water: Water that is on the earth's surface, such as a stream, river, lake or reservoir.

Sustainable: maintain (without adverse effect)

Topography: The shape and height of the land surface.

Total Dissolved Solids (TDS): The amount of dissolved material in water, usually expressed as milligrams per litre (mg/L).

Unconsolidated: A sedimentary deposit in which the particles are not cemented together.

Watertable: Level of the surface of the groundwater. It is often measured in observation bores.

Water quality: Physical, chemical, biological characteristics of water and how they relate to it for a particular use.

Water Year: The water year splits the year from September of one year to August of the next year. Hence the total Wet season rainfall is accounted for.

Yield: Amount of water which can be supplied by an aquifer or pumped from a bore over a certain time period.

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GEOLOGY MAPS (Geology maps and explanatory notes are attainable from the Northern Territory Geological Survey (NTGS) details at www.minerals.nt.gov.au/ntgs T:89996443)

APPENDIX A BORE DATA USED IN PRODUCTION OF THE WATER RESOURCES MAP

SITE	East	North	RLNS	Depth	SWL	RWL	Yield	Depth To Mullaman Beds	Depth to Anthony lagoon Beds	Depth to Gum Ridge	Depth to Nutwood Volcanics	Depth to Bukalara Sandstone	Depth to Proterozoic	Aquifer (Oldest to youngest formation)
RN001485	391926.8	8244666.2	181	23									0	Proterozoic
RN030500	380126.8	8290165.9	219	48	20	199	3	12					18	Proterozoic
RN007189	408826.7	8242566.2	159	76	0	159	3				0	55		Bukalara Sandstone
RN007190	408726.7	8252266.1	144	32	4	140	4.5					0		Bukalara Sandstone
RN007688	422376.6	8244966.2	229	58	3	226	0.9					0		Bukalara Sandstone
RN007689	401676.7	8261766.1	136	67			2.5				3	61		Bukalara Sandstone
RN007690	400126.7	8252416.1	166	95	6	160	5				3	79		Bukalara Sandstone
RN007692	412976.7	8233866.3	171	117	27	144	2.2	3			11	76		Bukalara Sandstone
RN009379	398926.7	8278366	132	61	16	116	1.8				3	36		Bukalara Sandstone
RN023165	402826.7	8277866	122	89	12	110	2.7				0	8		Bukalara Sandstone
RN023166	403026.7	8280566	118	70	18	100	0.7				0	18		Bukalara Sandstone
RN025384	392926.7	8284865.9	132	50	11	122	4				0	9		Bukalara Sandstone
RN025385	402726.7	8273366	113	67	11	103	3				0	6		Bukalara Sandstone
RN027189	398926.7	8278366	132	116	34	98	3				0	54		Bukalara Sandstone
RN030185	393926.8	8249166.1	178	102	27	151	2.3	6			11	94		Bukalara Sandstone
RN030186	413826.6	8246216.2	185	48	30	155	1.8					15		Bukalara Sandstone
RN030187	406726.7	8253366.1	143	60			1.5				2	45		Bukalara Sandstone
RN034177	412130	8233575	182	108	23	160	0.3	0			21	90		Bukalara Sandstone
RN034178	419443	8247367	187	40	3	184	0.8	0				9		Bukalara Sandstone
RN034179	395929	8255014	179	150	22	158	5	3			12	141		Bukalara Sandstone
RN034180	398553	8262477	146	138	14	132	3				0	93		Bukalara Sandstone

SITE	East	North	RLNS	Depth	SWL	RWL	Yield	Depth To Mullaman Beds	Depth to Anthony lagoon Beds	Depth to Gum Ridge	Depth to Nutwood Volcanics	Depth to Bukalara Sandstone	Depth to Proterozoic	Aquifer (Oldest to youngest formation)
RN034181	396237	8269028	173	150	25	148	3				0	141		Bukalara Sandstone
RN034183	403003	8277924	122	143	20	103	2					0	102	Bukalara Sandstone
RN009378	393226.7	8282265.9	140	45	4	136	2.8				3			Nutwood Volcanics
RN023164	402826.7	8277866	122	120	14	108	1				0	85	111	Nutwood Volcanics
RN000552	327527.3	8120116.9	231		76	155	0.6							Gum Ridge
RN000559	330577.3	8155016.7	231		76	155	1.8							Gum Ridge
RN000636	322777.3	8148416.7	232				1.8	3		55				Gum Ridge
RN000645	380776.9	8232966.2	202	68	68	134	1.4	3		46				Gum Ridge
RN000646	402576.7	8233166.3	175	34	27	148	1.8	2		14				Gum Ridge
RN000879	391326.8	8223066.3	192	55			2.5	2		37				Gum Ridge
RN000880	420326.6	8230466.3	190	34				3		17	34			Gum Ridge
RN002263	323777.3	8129166.8	230	34			1.2	2		27				Gum Ridge
RN002877	405926.7	8223366.3	203	72			2.6	0		25				Gum Ridge
RN005761	344327.1	8196966.4	257	97	90	167	2.5	23		79				Gum Ridge
RN006066	414226.7	8181216.6	310	168	155	155	1.6	3		128				Gum Ridge
RN007691	395326.8	8232126.3	176	76	27	149	2.2	3		12	43			Gum Ridge
RN021114	316577.4	8133516.8	230	99	76	154	1.1	9		30				Gum Ridge
RN021115	323727.3	8113466.9	229				2.3							Gum Ridge
RN023292	330377.3	8113916.9	228		86	142	0.3							Gum Ridge
RN023333	324577.3	8142166.8	231	103	77	154	2.5	0						Gum Ridge
RN023334	338177.2	8155816.7	228	103	73	155	3	6		75				Gum Ridge
RN023713	299433.5	8151003	244	109	85	160	5.4	0		60				Gum Ridge
RN024538	291127.5	8156167	250	100	73	177	3	3		54				Gum Ridge

SITE	East	North	RLNS	Depth	SWL	RWL	Yield	Depth To Mullaman Beds	Depth to Anthony lagoon Beds	Depth to Gum Ridge	Depth to Nutwood Volcanics	Depth to Bukalara Sandstone	Depth to Proterozoic	Aquifer (Oldest to youngest formation)
RN024539	288127.5	8144167	232	113	73	159	2	0		67				Gum Ridge
RN024815	262127.7	8145437	251	160	89	162	1	0		88				Gum Ridge
RN025208	369826.9	8238266.2	217	102	73	144	3	6		66	93			Gum Ridge
RN025710	340377.2	8149516.7	232	110	80	152	3	6		85				Gum Ridge
RN025997	330727.3	8155366.7	233	104	78	155	1.7	3		66				Gum Ridge
RN025998	369526.9	8239966.2	215	90	46	169	2	3		27				Gum Ridge
RN026719	344327.2	8162566.6	227	160	101	126	0.5	2		30				Gum Ridge
RN026720	348027.1	8172816.6	229	120			0.3	3		78				Gum Ridge
RN027302	324527.3	8136066.8	231	101	75	157	2	6		54				Gum Ridge
RN027303	314027.4	8129566.8	232	101	75	157	1.5	6		58				Gum Ridge
RN027304	344127.2	8161866.6	229	101			1.2	3		70				Gum Ridge
RN027940	365573.1	8150427.7	262	151	107	155	10	3		60				Gum Ridge
RN027941	365573.1	8150427.7	262	144	107	155	10	3		60				Gum Ridge
RN028222	321327.3	8148766.7	235	114	82	153	1.7	12		60				Gum Ridge
RN028223	351127.1	8172666.6	227	119	78	149	3.2	3		50				Gum Ridge
RN028303	349627.1	8161866.7	227	114	74	153	15	3		78				Gum Ridge
RN028313	410524.7	8203656.5	248	1150	96	152	2.5	0	59	76	182		554	Gum Ridge
RN028795	294996.5	8159175	236	114	81	155	4	0		60				Gum Ridge
RN030707	330527.3	8114066.9	227		73	155	2							Gum Ridge
RN032146	327527.3	8119366.9	229	93	76	154	8	6		60				Gum Ridge
RN033269	264914	8147156	267	150	107	160		0		67				Gum Ridge
RN033270	265851	8160007	277	153	115	162		0		80				Gum Ridge
RN033604	310962	8138857	230	120	73	157	2	4		54				Gum Ridge

SITE	East	North	RLNS	Depth	SWL	RWL	Yield	Depth To Mullaman Beds	Depth to Anthony lagoon Beds	Depth to Gum Ridge	Depth to Nutwood Volcanics	Depth to Bukalara Sandstone	Depth to Proterozoic	Aquifer (Oldest to youngest formation)
RN033606	345976	8185693	228	102	76	153	1.2	6		84				Gum Ridge
RN034175	381070	8232848	207	78	56	152	5	0		36				Gum Ridge
RN034176	386315	8227669	188	62	36	153	8	0		27	57			Gum Ridge
RN034182	376115	8229797	273	170	59	214	2.5	0		108	162			Gum Ridge
RN034442	298474	8141742	236	91	67	169		6		63				Gum Ridge
RN034443	287123	8145444	232	108	72	160	2	6		100				Gum Ridge
RN034479	323768	8113382	229	101	70	159	2.5	6		60				Gum Ridge
RN034480	340380	8143068	250	114	95	155	2.5	0		81				Gum Ridge
RN005844	377126.9	8194166.5	248	124	109	139	1.8	5	85					Anthony Lagoon Beds
RN005845	407294.8	8183306.6	313	147				9	126					Anthony Lagoon Beds
RN005954	401824.8	8185708.6	295	150	141	154	2.5	3	113					Anthony Lagoon Beds
RN006096	317127.4	8118266.9	227	81	.69	159	1	2	62					Anthony Lagoon Beds
RN006876	406088.8	8179565.6	282	140	110	172	1.6	3	107					Anthony Lagoon Beds
RN006877	403615.8	8178298.6	275	140	114	161	1.3	9	92					Anthony Lagoon Beds
RN008013	396643.8	8172759.6	272	162	106	166	1.3	2	92					Anthony Lagoon Beds
RN009351	317727.4	8113166.9	227	90	73	154	1.9	6	60					Anthony Lagoon Beds
RN023293	334327.3	8117466.9	244	110	90	154	1.4	0	95					Anthony Lagoon Beds
RN023294	330377.3	8113916.9	228	106				0	84					Anthony Lagoon Beds
RN027846	417276.7	8181916.6	304	179				3	105					Anthony Lagoon Beds
RN027847	418526.7	8181266.6	309	200				3	125					Anthony Lagoon Beds
RN028085	414132.7	8181214.6	312	178	142	170	10	6	122					Anthony Lagoon Beds
RN030503	426926.6	8181566.6	281	159	121	160		6	102					Anthony Lagoon Beds
RN032232	403526.8	8144366.8	249	126			4	0	86					Anthony Lagoon Beds

SITE	East	North	RLNS	Depth	SWL	RWL	Yield	Depth To Mullaman Beds	Depth to Anthony lagoon Beds	Depth to Gum Ridge	Depth to Nutwood Volcanics	Depth to Bukalara Sandstone	Depth to Proterozoic	Aquifer (Oldest to youngest formation)
RN032233	395926.8	8192566.5	288	150	103	185		5	91					Anthony Lagoon Beds
RN033484	408961	8154766	243	128	92	151	2.5	0	84					Anthony Lagoon Beds
RN034292	393985	8189391	291	174	139	152	1.4	0	124					Anthony Lagoon Beds
RN034293	403616	8178309	275	150	115	160	1.6	0	100					Anthony Lagoon Beds
RN036471	333800	8116791		273.9	83.96		25							Anthony Lagoon Beds
RN005846	421347.7	8179672.6	307	99				11						Mullaman Beds
Balmain1	348386	8161769	227	1046				0	49	78	260	343	401	Null
Mason1	365555	8150630	261	1098				0	59	117	341		468	Null
RN000591	311213.4	8109582.9	225		67	158	1.1							Null
RN000592	311213.4	8109582.9	225		70	155	2.3							Null
RN000644	386126.8	8252166.1	207	24										Null
RN000877	416326.6	8246466.2	179	13							12			Null
RN000878	419626.6	8247686.2	188	21			0.6					10		Null
RN000881	401826.7	8251766.1	165											Null
RN001486	416126.6	8232366.3	180											Null
RN001487	392426.8	8254266.1	180											Null
RN002264	327327.3	8120216.9	234											Null
RN002265	344407.2	8162566.6	227	93			1.5							Null
RN002876	379326.9	8222866.3	199	52			1.2							Null
RN002878	385326.8	8256766.1	177	158			2.5	0			16	120		Null
RN004596	331477.3	8137266.8	232				0.2							Null
RN004883	408726.7	8252266.1	144											Null
RN005793	323527.3	8113566.9	228											Null

SITE	East	North	RLNS	Depth	SWL	RWL	Yield	Depth To Mullaman Beds	Depth to Anthony lagoon Beds	Depth to Gum Ridge	Depth to Nutwood Volcanics	Depth to Bukalara Sandstone	Depth to Proterozoic	Aquifer (Oldest to youngest formation)
RN021113	348227.1	8169166.6	229				1.5							Null
RN023330	332177.3	8132766.8	250	103	87	163	2							Null
RN026718	344327.2	8162366.6	228	104	9	219	0.5	3						Null
RN027535	410530	8203194	249	1145				0	59	76	182		554	Null
RN027958	368449	8144837	261	1765				0	65	133	370	473	499	Null
RN028311	410525.7	8203479.5	249	56	18	232	1.5							Null
RN028312	410426.7	8203479.5	248	30										Null
RN029778	396126.8	8227166.3	199	105	48	151	0.3	3		15				Null
RN030501	380126.8	8280165.9	184	84				0					3	Null
RN27534	370007	8239017		102										Null
RN27534	369989	8238967	213	1698				0		74	97	318	390	Null
Shortland1	360077	8148010	264	1017				0	60	121	352	484	487	Null

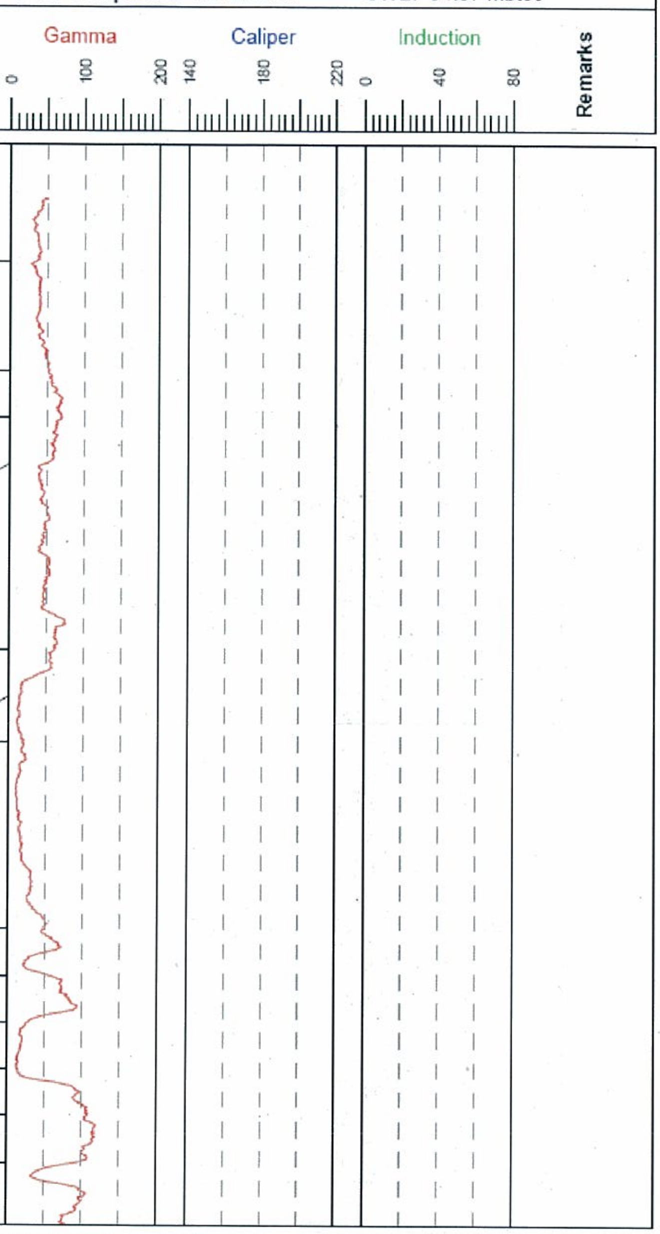
APPENDIX B DETAILED LOG OF RN036471

Gulf Water Study

Bore No. RN036471

Northing: 8116795
Easting: 333994
Geologist: Simon Fulton
Driller: Ian McMasters
Date Started: 05/12/2008
Date Completed: 12/12/2008
Total Depth: 274m
SWL: 84.07 mbtoc

Depth (m)	Stratigraphy	Lithology Description
0	Tertiary	LATERITE Clay dark red with nodular ironstones
10	Mullaman Beds (Cretaceous)	SILTSTONE, Silicified, light brown, hard, with quartz, feldspar and minor muscovite
	Mullaman Beds (Cretaceous)	SILTSTONE, yellow
	Mullaman Beds (Cretaceous)	SILTSTONE, light brown, interbedded with thin layers of fine grained sandstone
20	Mullaman Beds (Cretaceous)	SILTSTONE, yellow
30	Mullaman Beds (Cretaceous)	SANDSTONE, light brown, fine grained, predominantly sub rounded quartz and feldspar
	Mullaman Beds (Cretaceous)	SANDSTONE, quartzose, white, very fine grained, soft, minor feldspar
40	Mullaman Beds (Cretaceous)	SILTSTONE, white
50	Mullaman Beds (Cretaceous)	SANDSTONE, quartzose, white, very fine grained, soft, minor feldspar
	Mullaman Beds (Cretaceous)	SILTSTONE, light brown with seam of white sandstone
	Mullaman Beds (Cretaceous)	SANDSTONE, quartzose, light brown, fine grained
		SILTSTONE, light brown, silicified, calcareous
60		SILTSTONE, light brown
		SANDSTONE, light brown, fine grained, predominantly sub rounded quartz and feldspar



Construction Detail

8 inch steel casing (0 to 5.65m)

6 inch steel casing (5.65 to 143m)

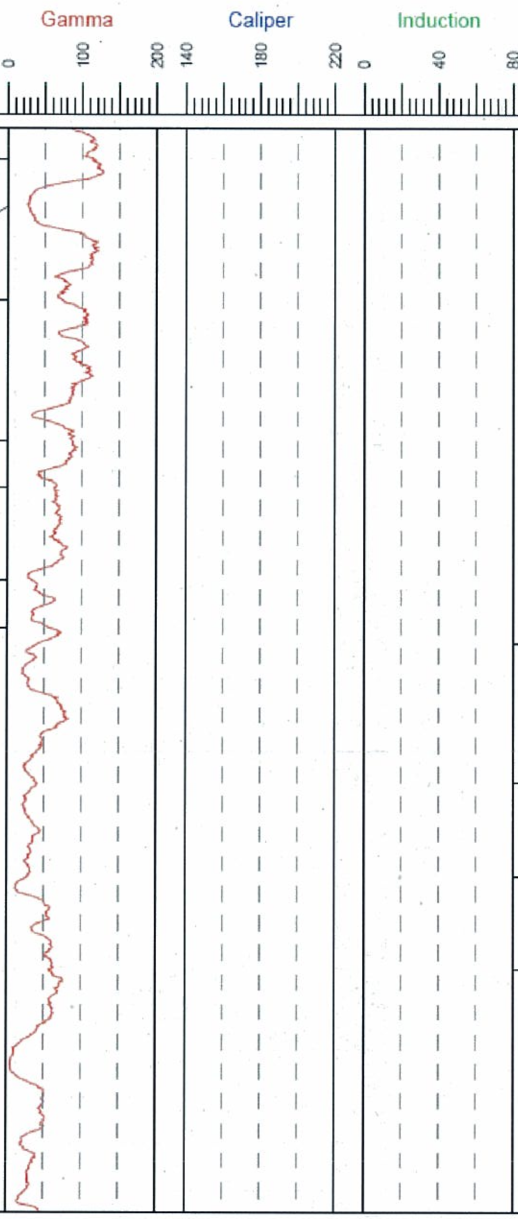
$5^{7/8}$ inch open hole (143 to 274m)

Gulf Water Study

Bore No. RN036471

Northing: 8116795	**Geologist:** Simon Fulton	**Date Started:** 05/12/2008	**Total Depth:** 274m
Easting: 333994	**Driller:** Ian McMasters	**Date Completed:** 12/12/2008	**SWL:** 84.07 mbtoc

Depth (m)	Lithology Description	Remarks
~68–70	SILTSTONE, red	
~70–73	SANDSTONE, light brown, fine grained, predominantly sub rounded quartz and feldspar	
~73–79	SILTSTONE, brown	
~79–88	SANDSTONE, quartzose, light brown, silicified, very fine grained, minor chert	Seepage, 1186 EC, 8.4 pH
~88–91	SILTSTONE, brown, friable	
~91–97	SANDSTONE, light brown, calcareous, contains minor chert and angular quartz crystals	
~97–100	SANDSTONE with minor limestone fragments	
~100–137	SANDSTONE with interbedded laminated mudstone seams	2.2 L/s, 1440 EC, 8.28 pH; 3.2 L/s, 1593 EC, 8.61 pH; 10 L/s, 1605 EC, 8.19 pH; 1645 EC, 8.28 pH



Construction Detail

8 inch steel casing (0 to 5.65m)

6 inch steel casing (5.65 to 143m)

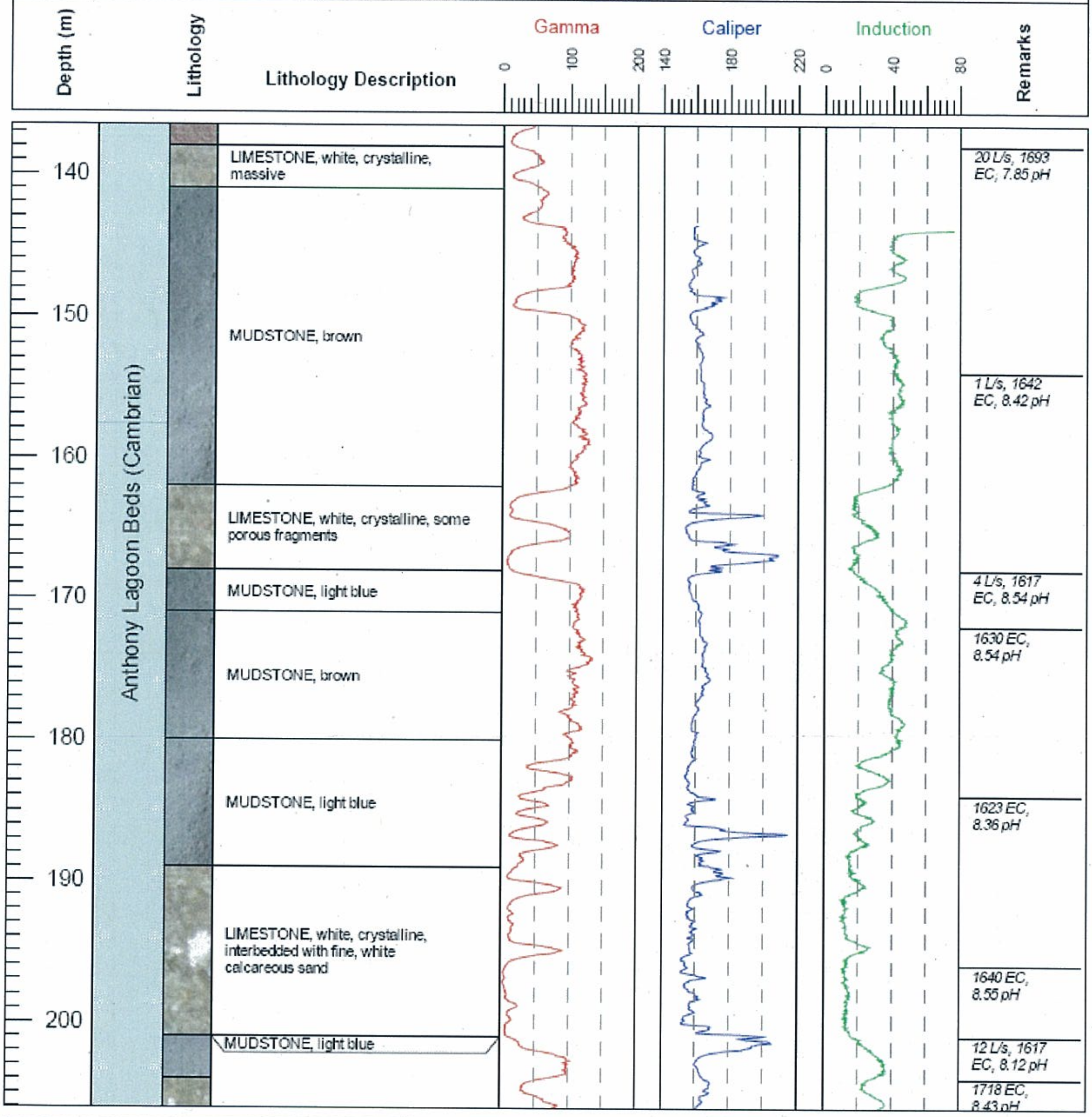
5[7/8] inch open hole (143 to 274m)

Page 2 / 4

Gulf Water Study

Bore No. RN036471

Northing: 8116795	**Geologist:** Simon Fulton	**Date Started:** 05/12/2008	**Total Depth:** 274m
Easting: 333994	**Driller:** Ian McMasters	**Date Completed:** 12/12/2008	**SWL:** 84.07 mbtoc



Construction Detail

8 inch steel casing (0 to 5.65m)

6 inch steel casing (5.65 to 143m)

5[7/8] inch open hole (143 to 274m)

Gulf Water Study

Bore No. RN036471

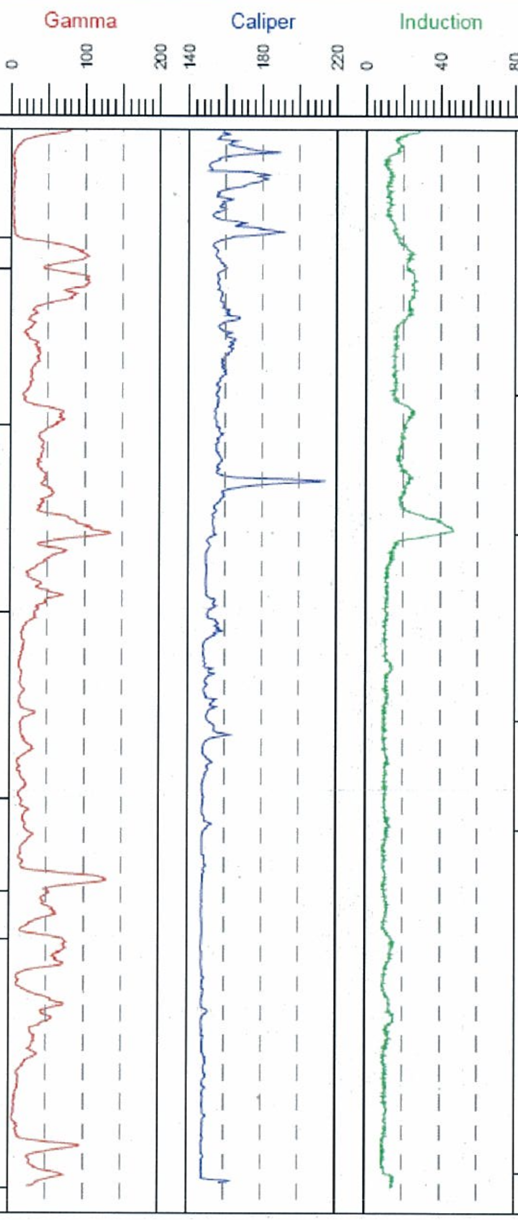
Northing: 8116795	**Geologist:** Simon Fulton	**Date Started:** 05/12/2008	**Total Depth:** 274m
Easting: 333994	**Driller:** Ian McMasters	**Date Completed:** 12/12/2008	**SWL:** 84.07 mbtoc

Depth (m) | Lithology | Lithology Description | Gamma | Caliper | Induction | Remarks

Depth (m): 210, 220, 230, 240, 250, 260, 270

Lithology Description

- LIMESTONE, white, crystalline, massive
- MUDSTONE, light blue
- LIMESTONE, grey, crystalline
- LIMESTONE, white, crystalline with interbedded mudstone
- SAND, white, fine grained, calcareous with bands of white limestone
- LIMESTONE, white, hard
- MUDSTONE, light blue
- LIMESTONE, white, interbedded with minor brown mudstone



Remarks

- *1713 EC, 8.33 pH*
- *1685 EC, 8.34 pH*
- *1750 EC, 8.44 pH*
- *Lost Circulation*

Construction Detail

8 inch steel casing (0 to 5.65m)

6 inch steel casing (5.65 to 143m)

5⁷/⁸ inch open hole (143 to 274m)

APPENDIX C DEPARTMENTAL WATER RESOURCE REPORTS

Scan No:	NRD No:	Title	Type	Area	Author
WRD84056	56/84D	Bore completion – Hodgson River Outstation	GW	Hodgson River	Karp, D
WRD88010	10/88d	Baseflow Water Quality Surveys in Rivers in the NT Vol.11. Roper, Wilton & Hodgson Rivers	SW		
WRD88046	46/88D	Bore Completion Report, RN 25384, Hodgson River DLH-600 Outstation	GW	Hodgson River	Verma, M
WRD04020	20/2004D	Assessment of Groundwater Resources on Hayfield and Shenandoah Stations	GW	Hayfield-Shenandoah	Tickell, S
WRD88043	43/88D	Bore Completion Report, RNs 24815,24816 & 14817 Buchanan Highway	GW	Buchanan Downs	Karp, D

Reports can be viewed at:

http://www.nt.gov.au/landwater/index.jsp

APPENDIX D SUMMARY OF BORE INFORMATION

There are no bores in this map region which have been or are currently monitored by NRETAS.

The following bore summary data is provided in alphabetical order of station name.

Amungee Mungee

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN005773	NO CCE AMUNGEE MUNGEE STN	53	393986	8189403	3/06/1967	144.7	NA	dry	dry
RN005845	NO CCF AMUNGEE MUNGEE STN	53	407295	8183307	18/06/1967	147.2	NA	dry	dry
RN005846	NO CCG AMUNGEE MUNGEE STN	53	421348	8179673	1/08/1967	99	NA	NA	NA
RN005954	AMUNGEE MUNGEE STN	53	401825	8185709	27/10/1967	151	122	141.4	2.5
RN006066	ROAD BORE-CHAIN 90.6 CARPENTARIA HWY	53	414227	8181217	27/11/1967	167.8	131	155	1.6
RN006876	69/26 AMUNGEE MUNGEE STN	53	406089	8179566	17/08/1969	140.2	130	109.7	1.6
RN006877	69/27 AMUNGEE MUNGEE STN	53	403616	8178299	20/08/1969	140.2	135	114.3	1.3
RN008013	72/1 G.C. AMUNGEE MUNGEE	53	396644	8172760	21/07/1972	161.5	99	106	1.25
RN027846	ROAD BORE-CHAIN 93 CARPENTARIA HWY.	53	417277	8181917	9/10/1991	178.8	6.5	NA	No circulation
RN027847	ROAD BORE-CHAIN 95 CARPENTARIA HWY.	53	418527	8181267	21/10/1991	200	6.5	Dry	Dry
RN028085	WR ROAD BORE CHAIN 90.6 CARPENTARIA HWY	53	414133	8181215	28/05/1992	177.8	177.7	142	10 pumped
RN030503	NO 2/98	53	426927	8181567	7/05/1998	158.4	158.4	121	0
RN032232	NO 1/99	53	403527	8144367	30/09/1999	126	126	NA	4
RN032233	NO 2/99	53	395927	8192567	1/10/1999	150.2	150.2	102.7	NA

Amungee Mungee

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN033484	BULWADDY PAST Co AMUNGEE MUNGEE STATION	53	408961	8154766	19/08/2002	128	126	92	2.5
RN034292	BULWADDY PASTORAL Co (AMUNGEE MUNGEE STATION)	53	393985	8189391	5/12/2004	174	174	138.8	1.4
RN034293	BULWADDY PASTORAL Co (AMUNGEE MUNGEE STATION)	53	403616	8178309	7/12/2004	150	144	115.2	1.6

Buchanan Downs

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN023713	BUCHANAN DOWNS STATION STATION BORE	53	299434	8151003	18/11/1984	109	92	84.5	5.4, (3 pumped)
RN024538	A=43/86 BUCHANAN DOWNS STN	53	291128	8156167	30/06/1986	100	97	73	3
RN024539	A=42/86 BUCHANAN DOWNS STN	53	288128	8144167	15/07/1986	113	97	73	2
RN024815	ROADS DIVISION 1/87 BUCHANAN HWY	53	262128	8145437	24/04/1987	159.6	135.6	89	1
RN028795	HIDDEN VALLEY STN. ROAD BORE	53	294997	8159175	26/09/1993	114	114	80.8	4
RN033269	BHR000	53	264914	8147156	19/04/2002	150	150	106.8	No circulation
RN033270	AD-Rail	53	265851	8160007	16/04/2002	153	153	115	No circulation
RN034442	KALALA STATION (BRANIR PTY LTD)	53	298474	8141742	13/10/2004	91	80	67	NA
RN034443	KALALA STATION (BRANIR PTY LTD)	53	287123	8145444	27/10/2004	108	100	72	2

Hayfield

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN000552	NO 7B HAYFIELD STN	53	327527	8120117	NA	95.7	95.7	75.8	0.6
RN000591	NO 9 HAYFIELD STN	53	311213	8109583	NA	81.4	81.4	67.6	1.13
RN000592	NO 9 HAYFIELD STN	53	311213	8109583	1/09/1954	80.8	80.8	70.4	2.27
RN000636	DROUGHT RELIEF HAYFIELD STN	53	322777	8148417	9/10/1952	90.2	90.2	NA	1.8
RN002263	NO 3 HAYFIELD STN	53	323777	8129167	7/09/1952	91.5	91.5	27.5	1.2
RN002264	NO 7A HAYFIELD STN	53	327327	8120217	NA	NA	NA	NA	NA
RN004596	JOHNSONS HAYFIELD STN	53	331477	8137267	NA	64.3	64.3	NA	0.22
RN005793	STUART PLAINS HAYFIELD STN	53	323527	8113567	NA	76.2	NA	NA	NA
RN006096	HAYFIELD NO 1 HAYFIELD STN	53	317127	8118267	19/01/1968	80.7	62.5	68.5	1
RN009351	HAYFIELD STN	53	317727	8113167	19/07/1978	91	91	73	1.9
RN021114	DUDLEY NO 2 HAYFIELD STN	53	316577	8133517	1/10/1981	98.5	98.5	76	1.1
RN021115	A=83/80 HAYFIELD STN	53	323727	8113467	30/11/1980	99	99	NA	2.27
RN023292	HENRY AND WALKER NO 1 HAYFIELD STN	53	330377	8113917	18/08/1984	134	NA	86	0.2
RN023293	HENRY AND WALKER NO 2 HAYFIELD STN	53	334327	8117467	19/08/1984	110	110	90	1.4
RN023294	HENRY AND WALKER NO 3 HAYFIELD STN	53	330377	8113917	22/08/1984	106	Nil	Dry	Dry
RN023330	HENRY AND WALKER HAYFIELD STN	53	332177	8132767	28/02/1985	103	103	87	2
RN023333	A=20/85 HAYFIELD STN	53	324577	8142167	23/03/1985	103	103	77	2.5
RN027302	DUPLICATE NO.2 HAYFIELD	53	324527	8136067	21/07/1991	101	101	74.5	2
RN027303	DUPLICATE DUDLEY NO.1 HAYFIELD	53	314027	8129567	3/08/1991	101	101	75	1.5
RN028222	DEVIL'S BORE HAYFIELD	53	321327	8148767	21/08/1992	112	112	82	1.7

Hayfield

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN030707	WEANER STOCK BORE NO.2 HAYFIELD STATION	53	330527	8114067	17/05/1997	102	102	72.5	2
RN032146	OLD NO 7 BIRDUM BORE	53	327527	8119367	28/04/1999	93	93	75.5	8
RN033604	A.P.N. PTY LTD	53	310962	8138857	16/10/2002	120	120	73.4	2
RN034479	DYER (HAYFIELD STATION)	53	323768	8113382	7/06/2005	101	101	70.4	2.5

Hodgson River

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN009378	A=32/78 HODGSON RIVER STN	53	393227	8282266	26/08/1978	45	45	4	2.8
RN009379	A=33/78 HODGSON RIVER STN	53	398927	8278366	27/08/1978	61	61	16	1.8
RN023164	HODGSON RIVER 1/84 HODGSON RIVER STN	53	402827	8277866	19/08/1984	120	63.4	14.1	1
RN023165	HODGSON RIVER 2/84 HODGSON RIVER STN	53	402827	8277866	21/08/1984	88.5	88.7	12.2	2.7
RN023166	HODGSON RIVER 3/84 HODGSON RIVER STN	53	403027	8280566	23/08/1984	70.2	3.5	18	0.7
RN025384	FLICKS WATERHOLE 1/87 HODGSON RIVER STN	53	392927	8284866	17/10/1987	49.5	50	10.5	4 (pumped)
RN025385	HART H HODGSON RIVER STN	53	402727	8273366	19/10/1987	67	61	10.5	3
RN027189	DUPLICATE NO.1 A=90/145 HODGSON RIVER	53	398927	8278366	22/10/1990	116	116	34	3
RN030500	E.F. & E.D. HART BORE No 1/98 HODGSON RIVER STATION	53	380127	8290166	2/05/1998	48	48	20.1	3
RN030501	E.F. & E.D. HART BORE No 2/98 HODGSON RIVER STATION	53	380127	8280166	3/05/1998	84	Nil	Nil	Nil
RN034183	HART (HODGSON RIVER STATION)	53	403003	8277924	19/11/2004	143	143	19.5	2

Nutwood Downs

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN000644	NO 4 NUTWOOD DOWNS STN	53	386127	8252166	2/07/1952	24.1	Nil	Dry	Dry
RN000645	NO 5 NUTWOOD DOWNS STN	53	380777	8232966	10/08/1952	67.7	NA	67.7	1.4
RN000646	NO 6 NUTWOOD DOWNS STN	53	402577	8233166	1/01/1952	33.5	33.5	27.1	1.8
RN000877	NO 7 NUTWOOD DOWNS STN	53	416327	8246466	1/06/1955	12.5	Nil	NA	NA
RN000878	NO 8 NUTWOOD DOWNS STN	53	419627	8247686	1/08/1955	20.7	NA	NA	0.6
RN000879	NO 9 NUTWOOD DOWNS STN	53	391327	8223066	1/09/1955	55.1	NA	NA	2.1
RN000880	NO 10 NUTWOOD DOWNS STN	53	420327	8230466	1/10/1955	34.4	Nil	NA	NA
RN000881	NO 11 NUTWOOD DOWNS STN	53	401827	8251766	1/01/1955	16.8	Nil	NA	NA
RN001485	NO 2 NUTWOOD DOWNS STN	53	391927	8244666	20/08/1968	22.9	NA	NA	NA
RN001486	NO 1 NUTWOOD DOWNS STN	53	416127	8232366	NA	38.7	NA	NA	NA
RN001487	NO 3 NUTWOOD DOWNS STN	53	392427	8254266	NA	26.5	NA	NA	NA
RN002876	BUDDY BUDDY NUTWOOD DOWNS STN	53	379327	8222866	1/05/1959	52	NA	NA	NA
RN002877	NB NUTWOOD DOWNS STN	53	405927	8223366	1/06/1959	78	78	NA	NA
RN002878	PIPE CREEK NUTWOOD DOWNS STN	53	385327	8256766	1/09/1959	158	NA	NA	NA
RN004883	HOMESTEAD WELL NUTWOOD DOWNS STN	53	408727	8252266	20/08/1968	NA	NA	NA	NA
RN007189	REVOLVER A=31/70 NUTWOOD DOWNS STN	53	408827	8242566	16/08/1970	76.2	76.2	0.3	3
RN007190	HOMESTEAD A=34/70 NUTWOOD DOWNS STN	53	408727	8252266	17/08/1970	32	32	4	4.5
RN007688	A=20/71 NUTWOOD DOWNS STN	53	422377	8244966	23/05/1971	57.9	57.9	3	0.9
RN007689	CHARLEY A=21/71 NUTWOOD DOWNS STN	53	401677	8261766	28/05/1971	67.1	67.1	Flowing	2.5
RN007690	MAHOGANY A=23/71 NUTWOOD DOWNS STN	53	400127	8252416	30/05/1971	94.5	94.5	6.1	5

Nutwood Downs

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN007691	HORSE CREEK A=24/71 NUTWOOD DOWNS STN	53	395327	8232126	18/05/1971	76.2	45.7	27.4	2.2
RN007692	ANDERSON A=32/70 NUTWOOD DWNS STN	53	412977	8233866	25/05/1971	117.4	117.4	27.4	2.2
RN025208	PACIFIC OIL AND GAS NUTWOOD DOWNS STN	53	369827	8238266	17/09/1988	102	102	73	3
RN025998	PACIFIC OIL & GAS NUTWOOD STN	53	369527	8239966	29/08/1989	90	72	46	2
RN027534	ALL TREE NO.1 NUTWOOD	53	370115	8239133	27/09/1988	1699.5	Nil	NA	12.6
RN028311	PACIFIC OIL & GAS 1/93 NUTWOOD DOWNS	53	410526	8203480	9/06/1993	56	34	17.5	1.5
RN028312	34001	53	410427	8203480	11/06/1993	30	Nil	NA	NA
RN028313	PACIFIC OIL & GAS 3/93 NUTWOOD DOWNS	53	410525	8203657	12/06/1993	138	138	95.7	2.5
RN029778	TANUMBIRINI STN.	53	396127	8227166	2/06/1994	105	NA	48	0.3
RN030185	SANDY CREEK BORE NUTWOOD DOWNS STATION	53	393927	8249166	1/06/1994	102	54	26.6	2.3
RN030186	STARKVALE BORE NUTWOOD DOWNS STATION	53	413827	8246216	1/07/1993	48	40	29.6	1.8
RN030187	TRIANGLE BORE NUTWOOD DOWNS STATION	53	406727	8253366	1/09/1992	60	35	Flowing	1.5
RN034175	DUNBAR (NUTWOOD DOWNS STATION)	53	381070	8232848	19/08/2004	78	78	55.5	5
RN034176	DUNBAR (NUTWOOD DOWNS STATION)	53	386315	8227669	6/09/2004	62	40	35.5	8
RN034177	DUNBAR (NUTWOOD DOWNS STATION)	53	412130	8233575	10/09/2004	108	108	22.5	0.3
RN034178	DUNBAR (NUTWOOD DOWNS STATION)	53	419443	8247367	12/09/2004	40	40	3	0.8
RN034179	DUNBAR (NUTWOOD DOWNS STATION)	53	395929	8255014	14/09/2004	150	150	21.5	5
RN034180	DUNBAR (NUTWOOD DOWNS STATION)	53	398553	8262477	24/09/2004	138	138	14	3
RN034181	DUNBAR (NUTWOOD DOWNS STATION)	53	396237	8269028	27/09/2004	150	156	25	3
RN034182	DUNBAR (NUTWOOD DOWNS STATION)	53	376115	8229797	9/11/2004	170	170	59	2.5

Shenandoah

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN000559	DUNMARRA NO 6 DUNMARRA HOTEL	53	330577	8155017	21/06/1948	100.3	100.3	75.8	1.8
RN002265	NO. 2 DUNMARRA DUNMARRA	53	344407	8162567	01/01/1930	92.9	92.9	NA	1.5
RN005761	NO CCB SHENANDOAH STN	53	344327	8196966	2/04/1967	96.7	96.7	89.9	2.5
RN005844	NO CCD SHENANDOAH STN	53	377127	8194167	27/05/1967	124	124	108.8	1.8
RN021113	BORE A 85/80 HAYFIELD STN.	53	348227	8169167	2/12/1980	107	107	NA	1.5
RN023334	A=19/85 HAYFIELD STN	53	338177	8155817	25/03/1985	103	103	73	3
RN025710	A=88/78 HAYFIELD STN	53	340377	8149517	10/06/1988	110	110	80	3
RN025997	ROADHOUSE BORE DUNMARRA	53	330727	8155367	24/08/1989	104	97.8	78	1.7
RN026718	DUPLICATE DUNMARRA NO 2 HAYFIELD	53	344327	8162367	10/09/1989	104	6	9	0.5
RN026719	A=89/103 DUPL DUNMARRA NO 2 HAYFIELD	53	344327	8162567	19/10/1989	160	6	101	0.5
RN026720	A=89/104 HAYFIELD	53	348027	8172817	22/10/1989	120	Nil	NA	0.25
RN027304	DUPLICATE DUNMARA NO.2 HAYFIELD	53	344127	8161867	6/08/1991	101	99	NA	1.2
RN027940	MASON-WATER WELL NO.1 HAYFIELD	53	365573	8150428	28/10/1991	151.3	145.2	107	10
RN027941	MASON-WATER WELL NO.2 HAYFIELD	53	365573	8150428	29/10/1991	136	136	107	10
RN027958	JAMISON-1 HAYFIELD	53	368610	8144943	17/10/1990	1767	Nil	106.7	NA
RN028223	COLLIN'S BORE HAYFIELD	53	351127	8172667	23/08/1992	119.4	119.4	78	3.2
RN028303	BALMAIN NO.1 HAYFIELD	53	349627	8161867	16/09/1992	114	114	74.1	15
RN033606	A.P.N PTY LTD	53	345976	8185693	19/10/2002	102	102	75.5	1.2
RN034480	DYER (SHENANDOAH STATION)	53	340380	8143068	10/06/2005	114	114	95.2	2.5

APPENDIX E BORE WATER CHEMISTRY

All groundwater contains various kinds of dissolved salts (minerals). Small quantities of many of these salts are essential to good health. Excessive concentrations however, can limit the uses of the water. Following is some information to help you interpret the water quality represented on the following pages. The information has been summarised from NRETAS technical fact sheet @ www.nt.gov.au/nreta/publications/natres/waterfactsheets.html. More information is available from this site.

Source of dissolves salts:

Salts in the water originate from minute quantities dissolved in rain water and from the chemical breakdown of rocks. Nitrate is also produced in the soil by natural biological activity. Over long periods of time evaporation concentrates them to varying degrees.

Guideline Values:

The maximum recommended values listed beside each salt are guidelines rather than strict limits. The reason for this is because there are often many factors governing how a particular salt affects the user. These can include a person's age and the total volume of water consumed. The guidelines given below are conservatively chosen in order to cover most situations. (Guideline values for stock noted in brown)

Fluoride 1.5 mg/L **(Stock 2 mg/L)**	This limit is based on health considerations. Excess fluoride can be removed by water treatment.
Hardness 200 mg/L (Aesthetic guideline only)	Hardness is a measure of the amount of calcium and magnesium in the water. Hard waters can cause the build up of scale in hot water pipes and fittings. They also require more soap to obtain a lather.
Iron 0.3 mg/L	Above this limit, taste may be unacceptable but it does not pose a health problem. High iron concentrations give water a rust brown appearance resulting in staining of laundry, pipe encrustation and odour problems. A common way to remove iron is to aerate the water by cascading it into a tank and allowing the iron to floc or settle.
Nitrate 50 mg/L **(Stock 400 mg/L)**	Based on health considerations a limit of 50mg/L is recommended for babies less than three months old and 100mg/L for older children and adults. Nitrate levels can be reduced if necessary by water treatment.
pH 6.5 - 8.5 **(Stock 5.5 – 9.0)**	This is a measure of the acidity or alkalinity. Values less than 6.5 indicate acidic water and can results in corrosion of pipes and fittings. When pH is more than 7.5, the water is alkaline and encrustation of pipes with calcium carbonate can occur. pH can be treated.
Total Dissolved Solids (TDS) 500 mg/L **(Stock 10000 mg/L)** **Chloride 250 mg/L** **Sulphate 250 mg/L** **(Stock 2000 mg/L)** **Sodium 180 mg/L**	Above these limits for TDS, chloride, sulphate and sodium, taste may be unacceptable but it does not pose a health problem. (Aesthetic guideline only) TDS is approximately equal to 0.6 x EC

The following bore water chemistry data is provided in alphabetical order of station name

Amungee Mungee

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN005954	19/11/1967	10774	1150	7.5	376	229	530	637	80	35		74	1	90	60	160	0.6	1		
RN006877	10/05/1975	12509	900	7.4	150	183	257	600	60	145	239	26	1	12	71	86	0.6		3	
RN008013	24/07/1972	15229	930	8	232	283	308	510	42	102	168	50	1	9	70	84	0.7	3.7	29	
RN028085	19/06/1992	51215	1285	7	370	451	587	830	141	100	165	57	1	11	66	213	0.4	0.1	26	
RN032232	30/09/1999	415	950	8.03	235.4	287	311	573	49	88	145	46	1	9	78	131	0.4	0.2	27	

Buchanan Downs

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN023713	23/04/1985	46446	1870	7.2	426	519	520			270	437									
RN023713	23/04/1985	46447	1870	7.2	426	519	494	1130	109	270	437	54	11	23	208	195	0.3	0.2	46	
RN023713	05/06/1998	159667	1899	6.6	432	527	542.6	1142	117	247	407	61	12	26	200	214	0.2	0.5	41	
RN024815	04/05/1987	47700	850	7.2	400	488	407	490	97	21	35	40	1	7	16	24	0.2	0.2	40	
RN024815	04/05/1987	47701	830	7.3	389	474	393	465	93	22	36	39	1	6	16	24	0.2	0.6	39	

Hayfield

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN000552	11/11/1955	761				654	440	1187	45	145		55	1.5	63	131	91	1.3			
RN000591	01/06/1956	881				556	494	2469	17	680		111	94	70	510	420	1.12			
RN000591	11/10/1965	882	3810	8.03	424	185	600	2860	32	853		124		125	575	64	1.5	0.2		
RN000592	11/10/1965	883	3810	8.03	424	185	600	2860	32	853		124		125	575	64	1.5	0.2		
RN000592	21/07/1967	884	2521	7.7	440	268	570	1582	85	480		86	0.4	55	425	225	1.05	0.8		
RN002263	22/01/1980	3845	1190	7.1	381	464	514	750	97	129	213	66	1	10	65	90	0.3	0.1	44	
RN002264	01/11/1955	3847			96	654	440		45	145		55	1.5	63	131	91	1.28			
RN002264	10/10/1968	3848	1250	7.7	422	257	360	800	28	144		49	10	34	135	79	1.6	0.1	54	
RN006096	19/08/1979	10881	1130	6.9	370	451	490	730	89	120	198	65	2	10	60	88	0.3	1.4	47	
RN006096	25/07/1983	10882	1840	8.7	326	397	276	1080	12	280	456	60	3	80	275	190	0.8	0.3	35	
RN009351	19/07/1978	20455	1980	7.7	417	509	370	1030	48	250	412	61	6	68	221	168	1.2	19	55	
RN009351	19/07/1978	20456	2000	7.7	431	525	379	1020	50	252	415	62	2	66	225	165	1.2	14	50	
RN021114	02/10/1981	38684	2430	7.3	372	454	520	1450	91	380		73	3	65	309	330	1.1		16	
RN021115	08/07/1983	38685	1450	7.8	460	561	395	870	64	150	242	60	2	61	142	106	1.3	1.2	39	
RN023292	20/12/1984	45336	1360	8	251	306	347	780	55	200	326	51	8	21	127	140	0.6	1.4	24	
RN023293	19/12/1984	45337	1510	7.8	322	393	403	870	66	210	351	58	5	20	143	150	0.6	4.2	29	
RN023294	22/08/1984	45338	1380	8.2	405	494	209	870	28	135	220	34	12	16	226	140	0.9	0.6	62	
RN028222	01/11/1991	51292	2150	7.9	396	483	419	1290	64	312	514	63	6	57	282	234	0.8	2.8	49	
RN030707	18/05/1997	159011	1749	6.7	251	306	477	1014	81	344	567	67	8	18	163	169	0.6		30	
RN032146	30/04/1999	409	464	7.6	233	284	245	294	44	8	13.2	33	1	2	9	29	0.3		23	
RN032146	01/05/1999	163798	1330	7.8	416	507	366	833	61	139	229	52	7	50	130	102	1.2	3.6	52	

Hodgson River

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN009378	27/08/1978	20703	1230	7.8	560	683	470	650	34	54	89	94	8	2	91	28	0.7	2	76	
RN009378	27/08/1978	20704	1230	7.8	570	695	460	640	33	48	79	92	9	3	91	22	0.7	21	75	
RN009379	28/08/1978	20705	360	7.5	150	183	125	210	17	8	13	20	1	12	20	9	0.3	15	60	
RN009379	28/08/1978	20706	350	7.8	140	171	122	240	16	10	16	20	1	29	19	4	0.2	5.7	63	
RN023164	20/08/1984	45127	630	7.5	184	224	198	370	40	66	107	24	1	12	42	44	0.3		30	
RN023164	20/08/1984	45128	650	7.4	184	224	194	380	40	68	110	23	1	12	54	45	0.3		31	
RN023164	20/09/1984	45129	810	6.7	173	211	203	450	42	114	188	24	1	12	78	64	0.3	1.5	30	
RN023165	25/09/1984	45130	700	6.8	144	175	176	390	36	94	155	21	1	14	66	60	0.3	2.7	21	
RN023166	23/08/1984	45131	500	7.3	237	289	187	290	32	14	23	26	1	15	29	9	0.4		32	
RN025384	17/11/1987	49047	610	6.9	320	390	300	380	68	10	16	34	1	4	20	16	0.2	0.8	50	
RN030500	02/05/1998	160622	45	6.9	10	12	6.6	94	1	6	10	1	1	3	4	5	0.2		32	

Nutwood Downs

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN000877	20/08/1968	1334	850	7.35	346	211	360	509	84	40		45		5	22	70	0.5	0.3	21	
RN000878	20/08/1968	1335	650	7.35	80	49	182	430	27	178		25		5	85	17	0.5	0.2	29	
RN000879	20/08/1968	1336	470	7.5	92	56	182	270	31	58		21		8	34	71	0.1		6	
RN001485	20/08/1968	2051	160	7.1	34	21	66	111	21	6		4		1	6	43	0.3		8	
RN001487	21/08/1968	2052	1150	7.35	354	216	430	795	115	88		58		10	90	210	0.6	2.3	19	

Nutwood Downs

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN002876	20/08/1968	5012	950	7.6	280	171	360	596	70	84		50		12	75	134	0.8		20	
RN002878	20/08/1968	5013	750	7.5	212	129	256	444	60	116		21		21	70	48	0.4	0.2	8	
RN004883	20/08/1968	8228	290	6.8	76	46	92	171	28	44		4		3	23	2	0.3		8	
RN007189	06/12/1970	13393	880	7.9	208	254	291	550	57	48		36	4	31	64	198	0.6	2.5	16	
RN007190	05/12/1970	13394	230	6.6	32	39	45	130	11	50		4	1	3	25	7	0.3	2.4	15	
RN007190	13/10/1981	13395	220	6.3	31	38	42	140	10	50		4	1	3	24	8	0.1	1.2	15	
RN007688	26/05/1971	14270	310	7.3	74	90	78	170	13	49		11	2	4	28	9	0.2	3.1	17	
RN007689	30/05/1971	14271	1660	7.6	240	293	542	1100	120	213		59	1	17	135	320	0.6	1.2	14	
RN007690	31/05/1971	14272	730	7.9	206	251	115	430	31	62		9	1	19	88	81	0.7	1	18	
RN007690	08/08/1971	14273	1580	7.7	367	447	391	950	66	213		55	6	32	178	156	0.7	0.1	38	
RN007691	22/05/1971	14274	2070	7.3	360	439	986	1640	204	160		116	6	20	108	650	1.2	1.9	23	
RN007692	28/05/1971	14275	2130	7.8	228	278	615	1510	85	223		98	2	36	224	665	2.3	2.7	23	
RN028311	25/06/1993	51332		6.11		2	15	37	1	20	32	3	1	1	9	3		0.1		
RN028313	25/06/1993	51333		7.92		304	412	565	99	65		40	1	7	52	120		0.1		
RN029778	03/06/1994	137579	498	6.9	288	351	292	231	51	5	8	40	1	2	4	8	0.2	0.1	24	
RN030185	10/09/1995	146382	719	7.9	241	294	279	429	59	16	26	32	1	11	41	143	0.4	0.1	18	
RN030186	12/09/1995	146383	125	6.4	33	40	16	73	3	10	16	2	1	7	14	12	0.2	18	14	
RN030187	10/09/1995	146384	1655	7.6	222	271	345	938	102	340	560	22	1	12	190	98	0.3	0.7	14	

Shenandoah

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN000559	11/10/1965	782	662	8.1	357	170	338	391	46	18		54		32	17			0.2		
RN000559	08/02/1968	783	694	7.6	290	177	308	470	26	56		58	0.6	22	45	30		1	45	
RN000559	27/08/1968	784	732	7.9	302	184	284	425	16	54		36	1	14	45	30	0.5	0.1	6	
RN000559	03/10/1968	785	650	7.3	278	170	280	370	33	56		34	1	12	45	30	0.7	0.7	40	
RN000559	15/02/1971	786	920	7.4	402	490	362			62										
RN000559	16/02/1971	787	960	7.9	406	495	406	630	95	69		41	2	17	55	44	0.2	0.1	40	
RN000559	19/02/1972	788	990	7.5	402	490	391	600	94	76		38	2	18	63	49	0.2	0.1	33	
RN000559	27/06/1972	789	1090	8.4	415	482	3	690	1	79		1	2	1	265	53	0.3	0.1	41	
RN000559	17/10/1974	790	1020	7.8	363	442	349	585	84	87	143	34	4	18	69	54	0.3	0.1	39	
RN000559	01/10/1975	791	1130	7.7	420	512	412	650	96	88	145	42	3	22	80	70	0.3	0.1	40	
RN000559	27/05/1977	792	1220	7.6	445	543	424	520	94	106	175	46	4	29	94	71	0.2	0.1	46	
RN000559	27/05/1977	793	1230	7.3	448	546	424	520	96	106	175	45	3	29	93	71	0.2	0.1	46	
RN000559	27/05/1977	794																		Bacto
RN000559	26/08/1977	795		6.8																Bacto
RN000559	30/09/1977	796	1230	7.1	431	525	417	710	88	108	178	48	3	30	96	82	0.2	0.1	47	
RN000559	30/09/1977	797	1220	7.1	431	525	414	690	90	106	175	46	4	29	95	81	0.3	0.1	47	
RN000559	23/08/1979	798	1230	7.3	443	540	430	770	98	108	178	45	4	30	95	84	0.4	0.1	45	
RN000559	06/03/1980	799	1580	6.9	438	537	445	793	104	127	209	45	4	32	105	96	0.3	0.1	45	
RN000559	23/10/1980	800		6.7																Bacto
RN000559	08/04/1981	801	1470	7.2	445	543	446	810	101	132	218	47	4	32	112	88	0.5	0.1	46	

Shenandoah

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN000559	08/04/1981	802																		Bacto
RN000559	17/06/1981	803																		Bacto
RN005761	01/06/1967	10176	1060	7.7	346	211	414	643	40	108		75		12	75	32	0.1	0.1		
RN005761	01/06/1967	10177	993	7.8	426	260	454	598	70	60		67		13	45	28	0.2	3.4		
RN005761	01/06/1967	10178	1202	7.2	416	254	482	757	90	94		61		8	77	55	0.1	2.8		
RN005844	14/08/1967	10561	1054	7.7	264	161	439	754	95	120		48	1	9	90	160	0.7	0.3		
RN005844	14/08/1967	10562	1085	7.8	256	156	382	735	95	118		35		9	88	220	0.3	4.4		
RN005844	16/09/1967	10563	1150	7.5	284	173	485	738	87	40		64		15	77	200	0.1	1		
RN005844	17/09/1967	10564	1110	7.7	274	167	515	722	87	40		71		15	82	200	0.1	9		
RN023334	26/03/1985	45387	1830	7.8	410	500	371	1070	58	250	410	55	6	57	238	155	1	6.5	35	
RN025710	11/06/1988	49291	960	7.8	299	365	315	570	47	94	155	48	4	26	76	79	0.8	0.4	51	
RN027940	29/10/1991	51134	360	8	191	233	209	232	49	3	5	21	1	2	3	13	0.1	3	47	
RN027940	31/10/1991	51135	455	7.4	245	299	254	290	57	3	5	27	1	2	2	9	0.1	0.2	49	
RN027941	02/11/1991	51136	420	7.5	226	275	240	270	53	3	5	26	1	2	2	9	0.1	0.5	49	
RN028223	01/11/1991	51293	960	7.9	230	280	333	568	64	101	166	42	1	10	78	69	0.4	3	29	
RN028303	02/06/1993	51328	58	6.2	4	5	7	93	1	14	23	1	1	1	9	5	0.1	3	68	

APPENDIX F SURFACE WATER SITES

Surface water sites include sites along a river, waterholes and springs.

The sites all lie within the Roper River basin (catchment), '903'.

None of these surface water sites are currently being monitored by NRETAS.

903 ROPER RIVER

STATION	STATION NAME	EASTING	NORTHING	DATE OF FLOW RECORD	FLOW L/s	SITE TYPE	COMMENT
Water quality sites, some have river flow measured							
G9030252	Arnold River At 4km U/s Minimere Lagoon	416827	8290266	16/06/1986	3	River	
G9035096	Hodgson River Station At Spring	403127	8277166		N/A	Spring	Located in river
G9035104	Arnold River At G 86	416927	8290266		N/A	River	
G9035133	MINIMERE LAGOON ARNOLD RIVER	412737	8295496		N/A	River	Permanent waterhole
G9035296	Kempsey Creek Spring 32km Sth of Minyerri Community	397828	8290573		N/A	Spring	Located in river
G9035422	Nutwood Downs Spring / Waterhole	408800	8251900		N/A	Spring	Permanent waterhole

APPENDIX G CHEMISTRY OF SURFACE WATER SITES

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)
G9035096	4/11/1977	116049	420	7.5	176	214	170			22	36								
G9035096	4/11/1977	116050	400	8	170	207	150			22	36								
G9035096	20/08/1991	116051	70	6.9	28	34	24	50	5	5	8	3	2	3	4	4	0.1	0.9	8
G9035104	16/06/1986	116064	30	6.4	6	7	7	35	1	8	12	1	1	1	4	1	0.1	1.1	14
G9035133	12/12/1994	140487	47.7	6.7	11	13													
G9035133	12/12/1994	151655	47.7	6.7	11	13													
G9035133	23/08/1995	152938	34	6.3	7.4	9													
G9035133	21/11/1995	153113	40	6.8	11	13													
G9035422	7/09/2007		217																

APPENDIX H RAINFALL RECORDER SITES

Station Number	Site	Easting	Northing	Commence	Cease	Status
DR014611	DUNMARRA ROADHOUSE	331293.3	8154967	31/08/1963		Open
DR014621	NUTWOOD DOWNS	409098.7	8251320	31/08/1935		Open
DR014712	Hodgson River	402817.2	8277703	31/07/1974		Open
DR015124	NEWCASTLE WATERS (HEYFIELD)	329754.3	8125443	31/12/1967	31/12/1973	Closed
DR015132	STURT PLAINS	324584.3	8106955	31/12/1966	30/06/1974	Closed

Sites are all located in zone 53, Datum MGA94.

Back Cover: Indigenous wooden food and water carrier – Coolamon or *Lujuluju* -purchased from Waralungku Arts, Borroloola


Daphne Mawson

Daphne Mawson, a Garrwa woman, related the following story about a coolamon of water. She lives in Borroloola and works at the Borroloola primary school teaching indigenous culture in Garrwa.

Story about the frog and the Pee Wee

Every night when I was little, my grandmother told me a story about the frog and the Pee Wee. It is a story of how the rivers came to be and not to be greedy. She said that a long, long time ago in the dreamtime there was a Pee Wee and a frog. The Pee Wee was the owner of a coolamon of water. He used to carry it around.

One day the Pee Wee camped under a tree and hid the Coolamon of water. The frog came to the Pee Wee to ask where he got water from. The Pee Wee said go north and the frog went north. In the evening he came back tired and weary and said there was no water there. 'Where did you get the water from' he asked? The Pee Wee replied 'ah I forgot, I got the water from the east'. So the frog went to the east and as he travelled he was getting very tired but he made it back to the Pee Wee. Once again he asked 'where did you get the water from'? The Pee Wee said 'Oh silly me, that's right I got it from the south'. Off he slowly went, he was getting very tired and very thirsty. But the frog still didn't find the water and went back to the Pee Wee. He asked the Pee Wee again, his lips were dry and parched, his voice was croaky 'Where did you get the water from'? The Pee Wee said 'I'm getting old, I keep forgetting, that's right, I got it from the west'. So off went the frog, he was very tired and dehydrated. By this time the Pee Wee was getting tired because he hadn't slept for days as he was guarding his coolamon from the frog. He fell asleep. Poor old frog slowly dragged himself back after not finding any water. He saw the Pee Wee had fallen asleep and grabbed a rock and smashed the coolamon. Water gushed everywhere and that's how the rivers were created. The Pee Wee woke up with a start and found his water gushing everywhere, he ran and grabbed the stick and bashed himself over the head crying for his water. Blood streamed all over his body and that's why today the black marks you see on the Pee Wee are the blood stains for when he cried for his water. Today when you hear the first storms you hear the frogs in the lagoons, that's the frogs teasing the greedy Pee Wee who wouldn't share his water.

This was the story my grandmother told to teach us to share everything, especially water which is needed for everyone's survival.