Power and Water Authority

WURANKUWU GROUNDWATER RESOURCE EVALUATION

A. Moser  
D. Chin  
Water Resources Division  
DARWIN NT  
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SYNOPSIS

A groundwater resource evaluation was conducted for the community of Wurankuwu on the western side of Bathurst Island in 1994 to develop a water supply for the community.

Two aquifer systems have been identified, one in Tertiary aged Van Diemen Sandstone and the other in a sandier facies of the Cretaceous aged Moonkinu Member. The Van Diemen Sandstone aquifer is an unconfined aquifer extending to approximately 18 m BGL with its water table at approximately 15 m BGL (29292, June 1994). Estimation of the supply potential of this aquifer system, based on assumed recharge rates and storage potential, suggest a sustainable yield of 430 kL/d/sqkm. To obtain a high yielding bore (approx. 3 L/s) from this aquifer downhole gamma logging is required to identify the interval to screen. Three bores have been constructed to exploit this aquifer, 29292, 29296 and 29297, however they yield only 0.5, 0.4 and 0.4 L/s respectively.

The Moonkinu Member aquifer is a leaky confined aquifer at a depth of approximately 105 m BGL (-45 m AHD). The potentiometric level of the aquifer is approximately 55 m BGL (5 m AHD) and it has an estimated sustainable yield of 6 L/s based on limiting the pumping cone of influence. Two bores have been constructed to exploit this aquifer, 29294 and 29295, at recommended rates of 2.0 L/s each.

A borefield configuration has been recommended to supply the community with a maximum flow of 2 L/s with 2 L/s stand-by. A monitoring programme has also been recommended along with irrigation supply options.
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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHD</td>
<td>Australian Height Datum</td>
</tr>
<tr>
<td>BGL</td>
<td>Below ground level</td>
</tr>
<tr>
<td>°C</td>
<td>degrees Celsius</td>
</tr>
<tr>
<td>ml</td>
<td>millilitre</td>
</tr>
<tr>
<td>L</td>
<td>Litre</td>
</tr>
<tr>
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<td>kilolitre</td>
</tr>
<tr>
<td>L/s</td>
<td>Litres per second</td>
</tr>
<tr>
<td>kL/d</td>
<td>kilolitre per day</td>
</tr>
<tr>
<td>L/c/d</td>
<td>Litres per capita per day</td>
</tr>
<tr>
<td>mm</td>
<td>millimetre</td>
</tr>
<tr>
<td>m</td>
<td>metre</td>
</tr>
<tr>
<td>km</td>
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</tr>
<tr>
<td>m²/d</td>
<td>metres squared per day</td>
</tr>
<tr>
<td>mg/L</td>
<td>milligrams per litre</td>
</tr>
<tr>
<td>ID</td>
<td>internal diameter</td>
</tr>
<tr>
<td>OD</td>
<td>Outer Diameter</td>
</tr>
<tr>
<td>ppm</td>
<td>parts per million</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinylchloride</td>
</tr>
<tr>
<td>RN</td>
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</tr>
<tr>
<td>Sₚ</td>
<td>Storage Coefficient</td>
</tr>
<tr>
<td>Sᵧ</td>
<td>Specific Yield</td>
</tr>
<tr>
<td>T</td>
<td>Transmissivity</td>
</tr>
<tr>
<td>SWL</td>
<td>standing water level</td>
</tr>
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<td>MSL</td>
<td>mean sea level</td>
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1. INTRODUCTION

During June and July, 1994, Water Resources Division conducted a groundwater resource evaluation of the Wurankuwu area on the western side of Bathurst Island to develop a water supply for the emerging community. A total of 8 bores were drilled to determine the groundwater potential of the area and five were subsequently completed as production bores.

This report documents the findings of the investigation and makes recommendations for the current and future utilisation of the groundwater resources.
2. HYDROGEOLOGY

The following subsections document the assessment and interpretation of available literature and the field results from drilling, downhole geophysics and test pumping. Full reports of the field activities are covered in Appendix A. All bores drilled during the project will be referred to by their registered number (RN) and include 29290-29297. See Figure 2 for bore locations.

2.1 Geology

There are two major units of hydrogeological significance on Bathurst Island. The Moonkinu Member is Mesozoic (Cretaceous) in age and consists of fine to very fine sublalie sandstone interbedded with grey carbonateous mudstone and siltstone. Calcareous and limonitic concretions have been noted throughout the unit. The Moonkinu Member was laid down in a shallow marine environment during a period of regressing sea (Hughes, 1976).

Earth movements during the Tertiary resulted in slight tilting in the area (to the north west). The fluvial Van Diemen Sandstone was deposited by rivers flowing across the area from highlands of Protobzoic rocks in the south to a coastline near the present day coastalines of the Tiwi Islands. The Van Diemen Sandstone unconformably overlies the Moonkinu Member and consists of friable, white to yellow, medium to coarse quartzose sandstone with lenses of siltstone and granular conglomerate deposited in fluvial and paralic environments.

Groundwater resources at Milikapiti (Snake Bay) on Melville Island were investigated and developed by Mason Et Al (1959), Britten (1988), and Chin (1991). In his report, Chin (1991) has identified the Van Diemen Sandstone as the major groundwater source at Milikapiti. He describes an upper unit of brown, tan, purple and white sandy clays, clays, and sand, and a lower unit of white and tan friable fine to coarse quartz sandstone with clayey matrix and interbeds of clay in which the majority of groundwater bores were developed, separated by a 10 to 20m weathered zone of lateritised ferruginous sandstone and mottled clays. Underlying the Tertiary is the grey mudstone identified throughout the islands as the Moonkinu Member, approximately the first meter of which was indurated. In the area of Banjo Swamp, several bores were developed in "sandy clays" above the grey mudstone which were re-interpreted as Moonkinu Member and differed in lithology and gamma log response to the Van Diemen Sandstone sediments and produced smaller yields of water.

Also noted in this report was the drilling of a test production bore 27923 which exploited a 6m thick interbed of moderately indurated sandstone within the Moonkinu Member at a depth of 124m below ground surface. The bore yielded a recommended discharge rate of 4 L/s, and it was noted that the water obtained was of a better quality especially in terms of pH, but that the limited data available on this aquifer did not ensure its sustainability.

A groundwater resource evaluation was carried out for Nguiu (Bathurst Island Mission) in 1992 (Yin Foo, 1992), and encountered similar conditions to those at Milikapiti. The Tertiary/Cretaceous contact was interpreted as the top of the grey mudstone, generally between 5 and 15m above mean sea level, but noted as varying up to 25m. Neither the basal conglomerate of the Van Diemen Sandstone nor the indurated mudstone at the top of the Moonkinu member were noted at Nguiu. The upper and lower units of the Van Diemen Sandstone noted at Milikapiti were not differentiated in the report, although brief perusal of the geological logs indicates that the units may be distinguished. The sandy facies at the top
Late (lithic silt)

VAN DIEMEN SANDSTONE

SANDY CLAY, fine - very fine, yellow-brown with occasional poorly iron cemented bands

CLAY: white with purple, yellow and brown mottle

MUD: dark grey with occasional thin buff claystone interbeds

MOONKINU MEMBER

MUD: dark grey, with 30-40% clayey sand, fine-very fine, white-yellow

LEGEND

--- LITHOLOGICAL BOUNDARY

--- INFERRED LITHOLOGICAL BOUNDARY

--- STANDING WATER LEVEL-SHALLOW AQUIFER

--- POTENTIOMETRIC LEVEL-DEEP AQUIFER

CROSS SECTION AA
of the Moonkinu Member recognised below Banjo Swamp at Milikapiti were not identified at Nguiu.

Oil Development NL conducted an auger sampling program on Bathurst Island in 1961 (R Hare and Associates, 1962b). The report described the Cretaceous sediments along the coastal cliffs approximately 10km north-west of Wurankuwu as consisting of grey clays at the exposed base grading up to white clays and siltstones which contain interbeds of ferruginous sandstone. The surface of the Cretaceous was described as undulating with channels eroded into it prior to deposition of a basal Tertiary conglomerate and overlying sands which cap the exposed Cretaceous sediments in a thin veneer and infill deeper channels eroded to a substantial depth below the present sea level.

The investigation recently completed at Wurankuwu included the drilling of 5 investigation bores and the completion of 5 production bores and indicates that the Van Diemen Sandstone is less than 20m thick at this locality. The thin veneers of basal Tertiary material noted in the cliff sections 10km to the north-west were found at Wurankuwu. The Van Diemen Sandstone, in which a shallow aquifer has developed, varied in thickness depending on the degree of erosion, and was comprised of sandy clays, fine to very fine, yellow-brown with occasional poorly iron cemented bands, underlain by more than 15m of white clays with purple, yellow and brown mottling. These were in turn underlain by dark grey mudstones, with interbedded clayey sands at depth. A deep aquifer has developed in one such interbed, similar to that encountered in 27923 at Milikapiti, and yielded larger supplies of groundwater.

The cross section compiled from the drilling and geophysical downhole gamma logging (Figure 3) shows the relatively flat bedding of the sediments, and the Tertiary Van Diemen Sandstone capping of the Cretaceous Moonkinu Member forming the escarpments around Mount Hurd.

2.2 Aquifer Parameters

Both the shallow and deep aquifers were test pumped to determine the hydraulic parameters of the bores and aquifers.

The shallow aquifer was first encountered in 29291, which was subsequently backfilled. 29292 was drilled adjacent to this and cased with 104mm ID PVC to evaluate the potential of the aquifer. A 6m slotted interval was positioned with the aid of gamma logging and a 6m sump was added to allow for pumping from below the slots due to the minimal available drawdown. The bore airlifted 1 L/s on completion and was test pumped up to 2 L/s. 29293 was drilled through the surface aquifer, but the aquifer was not tested in this location due to the small thickness of aquifer material available below the water table. 29294 was drilled into the deep aquifer, and dual 104mm ID PVC casing strings were run in the hole, one into the deep aquifer and one into the shallow. The shallow aquifer airlifted 0.5 L/s on completion, and was therefore not pump tested.

Two intended production bores were subsequently drilled into the shallow aquifer, 29296 approximately 35m south east of 29292, and 29297 approximately 55m north west. 154mm ID FRP casing was run with 4m of 154mm ID stainless steel screen of 0.5mm aperture located against the aquifer zone as defined by gamma logging. A 3m stainless steel sump was added to the casing to allow for pumping from below the screens. Each bore airlifted approximately 0.5 L/s on completion and were subsequently test pumped up to 0.5 L/s.
Table 2.2 Aquifer Parameters

<table>
<thead>
<tr>
<th>Pumped Bore</th>
<th>Test Type</th>
<th>Date</th>
<th>Discharge (L/s)</th>
<th>ObsBore</th>
<th>Distance (m)</th>
<th>Trans.(m²/d)</th>
<th>S/Sₜ</th>
<th>Comments</th>
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</thead>
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<tr>
<td></td>
<td>Step D/down</td>
<td>15/6/94</td>
<td>0.5</td>
<td></td>
<td></td>
<td>790(?)</td>
<td></td>
<td>Shallow aquifer. Jacob straight line approx. See text for explanation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
<td></td>
<td></td>
<td>790(?)</td>
<td></td>
<td>Jacob straight line approx.</td>
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<tr>
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<td>2.0</td>
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<td>55(?)</td>
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<td>Constant Dis.</td>
<td>16/6/94</td>
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<td>Shallow aquifer. Jacob straight line approx. See text for explanation.</td>
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<td>95</td>
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<td>Constant Dis.</td>
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<td>7.5(?)</td>
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<td>55</td>
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<tr>
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<td>Constant Dis.</td>
<td>13/7/94</td>
<td>0.4</td>
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<td>55</td>
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<td>Re-test after jetting. Jacob straight line approx.</td>
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<td>Step D/down</td>
<td>9/6/94</td>
<td>0.6</td>
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<td>-</td>
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<td></td>
<td></td>
<td></td>
<td>29294 34</td>
<td></td>
<td></td>
<td>0.9 x 10⁴</td>
<td></td>
<td>Theis type curve solution.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>29293 600</td>
<td></td>
<td></td>
<td>1.4 x 10⁴</td>
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</tr>
</tbody>
</table>
From the drilling results the shallow aquifer has been interpreted as being unconfined. The results from the test pumping also suggest the same, most notably the lack of response of close (<55m) observation bores during the constant discharge tests. The drawdowns from the pumped bores were analysed using Jacob's straight line approximation to obtain estimates of transmissivity. Estimation of specific yield was not possible as the cone of depression did not reach the observation bores. Values of transmissivity are summarised in Table 2.2.

The results from the step drawdown test on 29292 were not analysed as it appears that steady state was achieved in the first two steps and in the third step the drawdowns were erratic probably due to turbulent flow conditions as the water level dropped below the top of the screens. Only the early time (<10 minutes) data was analysed for the constant discharge test on 29296 to provide a minimum likely value of transmissivity as it appears that steady state was reached or the discharge rate was decreasing. Of the remaining values the transmissivity range is between 30 and 95 m/d. Considering that aquifer transmissivity is dependent on thickness of saturated sediments for unconfined aquifers an estimate for the bulk transmissivity of the shallow aquifer is 50 m/d.

Without data to estimate the specific yield of the shallow aquifer a conservative value of 5% is assumed based on a comparison with the Tertiary Van Diemen Sandstone at Milikapiti (S, of 10%, Chin 1991).

The deep aquifer was first encountered in 29290, but was not cased or tested due to a low airlift yield. 29293 was cased in the deep aquifer with 104mm ID PVC casing, slotted over a 6m length opposite the sandiest section as per the gamma log. Subsequent testing saw it pumped at rates up to 2 L/s. This bore was further used as an observation bore during the test pumping of 29295. 29294 was completed in a similar manner, and airlifted 4 L/s on completion, and was used as an observation bore during pump testing of 29295. 29295 was drilled to production specifications and cased with 154mm ID FRP casing was run with 4m of 154mm ID stainless steel screen of 0.5mm aperture located against the aquifer zone as defined by gamma logging.

Results from the test pumping of the deep aquifer were analysed assuming it is confined. The low value of 25 m/d from the last step of 29293 is due to it's construction (slotted PVC casing) and development during the test and is consequently disregarded. The remaining values of transmissivity range from 190 to 620 m/d and an estimate of 300 m/d for the average transmissivity has been adopted for subsequent calculations. Storage coefficients from the two observation bores monitored during the testing of 29295 are the first such values determined for the deep aquifers in the Moonkinu Member. Values of 0.9 x 10⁻⁴ and 1.4 x 10⁻⁴ indicate that an appropriate representative value for the deep aquifer is 1.0 x 10⁻⁴.

2.3 Groundwater Movement and Recharge

The shallow aquifer delineated in the cross section as sandy clay, can be seen to follow the topography of the upper plateau, but has been eroded away completely at the small escarpments which surround Mount Hard. Recharge is by direct infiltration through the lateritic soil, and discharge is by evapotranspiration and direct evaporation of seepage around the escarpments. In some instances, the seepage concentrates sufficiently to form springs, such as the one which currently supplies Wurankuwu's water supply, approximately 1km north of the community. It is probable that a depression or channel in the surface of the underlying
clays provides the concentration mechanism for the spring’s flow.

This aquifer is dependant on regular wet season rainfall for recharge, and water level monitoring should be carried out to observe aquifer response. Due to the small number of bores and the lack of surveyed levels there is insufficient data to accurately draw piezometric contours for the upper aquifer. Occurrence of the aquifer coincides with surface elevation greater than approximately 20 m AHD with the standing water level basically following the surface contours. As such the direction of regional lateral groundwater flow is most likely to be from the topographically high areas to the low areas. Discharge in the low areas is often in the form of seepage and spring discharges at the escarpment.

Direct infiltration recharge to the aquifer is likely to occur regionally. Without data on water level rises due to rainfall infiltration an indicative infiltration rate of 13% is assumed based on experience from Milikapiti and Nguiu. Also considering all rainfall records from both islands (Chin 1991) the average annual rainfall is assumed to be 1500mm. This equates to an annual volume of water of 195000 m³/sq.km. Extracted over 10 months this indicates a supply rate of 630000 L/day/sq.km (approx. 7 L/s continuous). Whilst this represents a plentiful supply, the thin and shallow nature of the aquifer combined with a low water table makes for bore construction difficulties and extraction limitations. Also with the topographic relief available there is likely to be constant discharge from the aquifer resulting in a limited resource by the end of the dry season. There is potential for exploitation of this aquifer and to ensure optimum bore construction it is recommended that downhole gamma logging be utilised due to problems of drill sample contamination.

The nature of the deep aquifer is less certain due to the small area in which investigation holes were drilled. Although the aquifer sands are well below sea level, the piezometric surface of the aquifer in 29293, 29294, and 29295 is slightly above mean sea level due to the confined nature of the aquifer. It is unclear whether the water level in 29290 reflects the piezometric surface of the deep aquifer of the standing water level in strata above, as the level was taken from an uncased open hole.

It would appear that recharge for the aquifer must be via direct infiltration from ground level both locally and remotely, however, the recharge zone has not been determined in this investigation. The top of the aquifer appears to be shallowing in 29290, and recharge may occur if it intersects the ground surface to the south or east of this point. This also gives rise to the possibility of direct contact of the aquifer to the sea, and the risk of salt water intrusion should the piezometric surface of the aquifer be decreased to below sea level by excessive pumping. If expansion of the borefield occurs in the future, investigations should be aimed at delineating the continuity and recharge areas of this aquifer. In the meantime, water quality must be carefully monitored in 29295 if it is utilised as a production bore.
2.4 Water Quality

All chemical water quality data obtained during this investigation is summarised in Table 2.4.

Water from both aquifers are very similar, with characteristics typical of NT coastal groundwaters. They have low total dissolved solids concentration (<50 mg/l), low pH (field pH ranging from 4.1 to 5.4) and low alkalinity (< 6 mg/l). The major constituents on the water, albeit in low concentrations, are sodium, silica, chloride, sulphate and bicarbonate.

Although very similar in quality, water from the two aquifers can be distinguished by pH (lower in the deep) silica (higher in the deep) and to a lesser degree sulphate (higher in the deep).

With the exception of pH the water is within the Guidelines adopted by the AWRC and NH&MRC. It should be highlighted however that the inherent corrosive nature of the water deserves attention when designing the reticulation system and that suitable non-corrosive materials be utilised.
TABLE 2.4 - WATER QUALITY DATA

Analyses in milligrams per litre (unless otherwise stated)

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3. DEMAND

At present, the demand for water at Wurankuwu is primarily for domestic consumption and sanitation. At the time of writing of this report, the population of the community was approximately 30-40 people accommodated in 7 houses. Building and expansion planned in the next year is expected to increase the population to approximately 100 people.

At the time of the field investigation the communities water supply was being drawn from a spring/soak to the north of the community (refer Figure 2). The spring was equipped with a solar pump and was capable of delivering an instantaneous flow rate of approximately 0.6 L/s into the elevated storage tank.

For the current population of 40, based on average and peak consumption rates of 0.8 kL/c/d and 1.2 kL/c/d, the demand would be 32 kL/d (ave.) and 48 kL/d (peak). For a population of 100, based on average and peak consumption rates of 0.8 kL/c/d and 1.2 kL/c/d, the demand would be 80 kL/d (ave.) and 120 kL/d (peak). As the community water demand depends on per capita consumption, monitoring of water consumed should be conducted to enable effective management of the resource. The data would also be valuable for a study of the pattern of consumption as the community establishes and develops which will be essential for future planning and augmentation of the water supply. Experience at communities on other parts of the Tiwi Islands indicates a highly variable and seasonal water demand.

Further demand is likely to come from irrigation requirements for an oval and garden. Some form of gardening has been proposed for the community, but the size and type of garden is unknown at this stage. Water requirements for the oval will be dependent on the watering system installed (manual or automatic).
4. BOREFIELD MANAGEMENT

With the current population of 40 expected to increase to 100 in the near future, a borefield configuration is recommended that will meet the variable demand. Of the available production bores, two exploit the deep aquifer and three the shallow. In the long term, the quantity of water required dictates the exploitation of the deep aquifer with mains powered pumps as the main source as the yields from the shallow bores are insufficient and the pumping level in the deep aquifer is excessive for the required rate using a solar installation.

To meet the demand of the community the following borefield configuration is recommended.

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<th>Rate (L/s)</th>
<th>Pump Setting (m)</th>
<th>Recommendation</th>
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<td>25.6</td>
<td>Do not equip.</td>
</tr>
<tr>
<td>29294</td>
<td>2.0</td>
<td>70</td>
<td>Equip as standby.</td>
</tr>
<tr>
<td>29295</td>
<td>2.0</td>
<td>70</td>
<td>Equip as main duty bore.</td>
</tr>
<tr>
<td>29296</td>
<td>0.4</td>
<td>24</td>
<td>Do not equip.</td>
</tr>
<tr>
<td>29297</td>
<td>0.4</td>
<td>24</td>
<td>Do not equip.</td>
</tr>
</tbody>
</table>

With this configuration the average and peak daily demands could be met by 29295 by varying the duration of pumping (11 hours/day for average demand, 17 hours/day for peak demand). The equipping of 29294 would provide standby capacity for pump or bore failure only. With this option it is necessary that the water quality from 29295 be carefully and regularly monitored to ensure the early detection, if any, of a decline in water quality to suggest the intrusion of the deep aquifer with saline water. The risk of saltwater intrusion is a result of the depth of the aquifer and a potentiometric level just above mean sea level. From this bore 3 monthly field conductivity and pH should be measured with water samples collected and analysed every May and November. Analyses should be for the major anions and cations, pH, specific conductance and TDS as in Table 2.4. Standard procedures should be followed when sampling. Should there be an increase in conductivity from successive measurements Water Resources Division should be notified.

It is possible that the irrigation requirements of the community could be supplied from springs/soaks in the vicinity of the community and/or the shallow aquifer in the vicinity of bores 29292, 29296 and 29297. The supply capacity of any spring/soak should be determined first by recession gauging to enable planning of any irrigation development.

An integral part of the management of the borefield is the regular monitoring of bore productions, borefield and regional water levels and water quality. It is recommended that use of bore production log sheets be instigated, along with monthly water level monitoring of 29290, 29293, 29294 and 29297. It is also recommended that the production bores have water level measuring devices installed to enable the monthly measurement of both static and operating water levels.
5. SUMMARY AND CONCLUSIONS

This groundwater resource evaluation has resulted in the drilling and construction of 5 production bores for the Wurankuwu community. A borefield configuration has been recommended, taking into account the available resources and the current and future demand.

Two aquifer systems have been identified, one in Tertiary aged Van Diemen Sandstone and the other in a sandier facies of the Cretaceous aged Moonkinu Member. The shallow aquifer in the Van Diemen Sandstone has developed in fine to very fine sandy clays with occasional iron cemented bands to a depth of approximately 18 m BGL. The aquifer is considered to be unconfined with its water table at approximately 15 m BGL (29292, June 1994), with a bulk transmissivity of 50 m²/d and specific yield of 5 %. The deep aquifer has developed in an interbed of clayey sands of the Moonkinu Member at a depth of approximately 105 m BGL (~45m AHD)(29295). The interbed is in dark grey mudstone and is considered to be a leaky confined aquifer. The potentiometric level of the aquifer is approximately 55 m BGL (5 m AHD) (29295, July 1994) and it has bulk transmissivity of 300 m²/d and storage coefficient of 1.0 x 10⁻⁶.

The shallow aquifer is likely to receive seasonal direct infiltration recharge and discharge naturally as a result of evapotranspiration and evaporation from seepage faces around the escarpment. Direction of groundwater flow is from topographically high areas to low areas. Recharge and groundwater movement for the deep aquifer is more complex. From the available data it is suggested that there is local recharge to the aquifer via the overlying sediments and possible remote recharge where the aquifer appears to be shallowing to the south and east. At this stage there is insufficient data to determine the existence or direction of throughflow. There is however a slight risk of saltwater intrusion of the deep aquifer due to its depth and low potentiometric level (just above MSL). From the experience of production bore 27923 at Milikapiti, which is exploiting an equivalent sequence of clayey sand at depth in the Cretaceous aged Moonkinu Member at up to 4 L/s without detriment, confidence is added to the decision to also exploit this deep aquifer.

Recommendations have been made to utilise production bore 29295, which exploits the deep aquifer, as the main supply for the community. The equipping of 29294 as a standby provides for pump/bore failure and the monitoring of water quality for early signs of possible saltwater intrusion. The pumping recommendations (rate and setting) for 29294 are based on the test pumping of 29295 as they exploit the same interval of the same aquifer and only a short distance separates them. The bore hydraulic parameters of 29294 should be determined by test pumping at the time of equipping. The current level of knowledge and development of the groundwater resources indicates that the available supply should not be used for irrigation purposes.

Water from both the aquifers is similar in quality and typical of water from NT coastal aquifers. Typified by low TDS, pH and alkalinity, it is corrosive in nature and as such suitable non-corrosive materials should be used throughout the reticulation system. With the exception of pH, the water is within guidelines adopted by AWRC and NH & MRC.

Supply for any irrigation purposes should consider springs/soaks in the vicinity of the community and/or the shallow aquifer using bores 29292, 29296 and 29297. A study is required to determine the quantity of water available from the springs/soaks.
6. RECOMMENDATIONS

Recommendations for the management of the borefield and groundwater resource are as follows:-

1. The borefield be developed/equipped as recommended in Section 4 of this report. Water from the borefield should not be used to meet irrigation requirements.

2. 29294 be test pumped when equipping to determine its hydraulic performance.

3. A monitoring programme be instigated to monitor water levels, production rates and water quality as outlined in Section 4. Special attention should be given to the monitoring of water quality from the main production bore 29295.

4. A study of springs/soaks near the community be carried out to determine their supply potentials for irrigation purposes.
7. REFERENCES


APPENDIX A
Wurankuwu Field Investigation - 1994
A1 Geophysics

Downhole geophysical logging of all bores was carried out after each bore was drilled. Initially, both nuclear and electric tools were run, however the electric logs were not run when it was found that the tool was ineffective in the 'Biogel' polymer mud used during drilling. The natural gamma logs of all the logged bores are included and were used to aid in the identification of facies changes within the sediments. 29291 could not be logged to total depth due to collapse and 29290 was not logged at all due to collapse.
Fig. A1(a) SPR and SP Logs 29291
Fig. A1(b) SPR, SP and Gamma Logs 29292
Fig. A1(c) SPR, SP and Gamma Logs 29293
Fig. A1(e) Gamma Log 29295
Fig. A1(f) Gamma Log 29296

Fig. A1(g) Gamma Log 29297
A2 Drilling

Drilling of all bores at Ranku was conducted using a top head drive drilling rig between May 24 and July 9, 1994. A total of eight bores were drilled, five for investigation (two of which were backfilled and the remainder cased), and three for production purposes.

RN29290

This bore was drilled at the base of a small escarpment approximately 700m west of the road between the community and the barge landing at approximately 20m elevation. It was drilled to its total depth of 84m on 25/5/94 using air with water and foam injection. At this depth, drilling was stopped due to collapsing sand. The hole could not be geophysically logged due to the collapse. As this was the first hole drilled and it did not intersect the intended target formation (Van Diemen Sandstone) and had a small airlift yield, it was backfilled rather than redrilling with mud for casing.

RN29291

As the elevation difference from RN29290 to the highest point in the Ranku area is only approximately 45m, RN29291 was drilled approximately 2.5km from the community adjacent to the Beach Road at the crest of Mt Hurd (elevation approximately 60m) to intersect the maximum thickness of target formation (Van Diemen Sandstone). The hole was drilled with air to total depth of 78m on 30/5/94 for speed and to get an indication of water flows. Although sandy facies were encountered in the hole, these were not consistent with Van Diemen Sandstone sediments and were determined to be sandier facies of the Moonkinu Member as observed elsewhere on the Tiwi Islands. On attempting to log the hole, the electric probe could only be run to 56m, and the gamma probe to 18m due to progressive collapse.

RN29292

With RN29291 collapsed, it was decided better to drill a separate hole to case and pump test the water indicated during the drilling of that hole. RN29292 was drilled 10m south of RN29291 from 31/5/94 to 2/6/94. Biogel polymer mud was used to prevent collapse of the bore during drilling and the hole was drilled at 10 inch diameter to allow for subsequent placement of gravel pack material. Although a total depth of 48.4m was drilled to gain better samples than during air drilling, the hole was backfilled to 29.4m before running 104mm ID uPVC casing. 6m of sump was placed at the end of the casing string preceded by 6m of finely slotted uPVC. The annulus around the slots was packed with graded fine granitic gravel from Mary River. Airlift testing yielded approximately 1.5L/s, pH 5.4, EC 45.7μS. Standing water level was approximately 14.5m.

RN29293

Since the Van Diemen Sandstone was not identified at the peak of Mt Hurd, it was decided to check the continuity of the shallow Moonkinu Member aquifer drilled in the previous two holes. RN29293 was drilled approximately 1.5km west of Ranku, at an elevation of approximately 50m from 2/6/94 to 7/6/94. It was soon apparent that if the standing water level was approximately the same as indicated in previous drilling, that there would be
insufficient thickness of sandy material to allow for construction of a bore in this material. It
was therefore decided to drill to depth through the previously encountered mudstones in
search of another aquifer. Sandy lenses were discovered at approximately 90m, and the was
drilled further to 126m for exploration purposes. An obstruction at 67m prevented logging of
the hole at the first attempt on 4/6/94. After cleaning out the hole, it was successfully logged
to 105m which was sufficient to run casing to the aquifer zone. A 104mm ID uPVC casing
string terminated with 6m of slotted casing and a 5m sump was run to 100.5m. The slots were
gravel packed and subsequent air lifting yielded approximately 3l/s, pH 4.1, EC 80μS.
Standing water level was approximately 47m.

RN29294

After a short break in drilling activities during which pump testing was conducted to assess the
-capacities of the two identified aquifers, it was decided to construct production bores within
both upper and lower aquifers. The deep site was chosen to reduce the depth of the bore, to
-further assess the distribution of sediments, to allow RN29293 to be used as a water quality,
-water level and salt water encroachment monitoring bore, and so that it would be close to any
-water reticulation line run to the shallow production bores on Mt Hurd.

RN29294 was drilled between 21/6/94 and 28/6/94 using polymer mud and a string including
stabilisers and reamers to increase the size of the hole to 12 inches to allow for the running of
154mm ID Fibreglass Reinforced Plastic (FRP) casing and filter pack. A total depth of 114m
was drilled to intersect the aquifer encountered in RN29293. The hole remained open to
108.5m and was logged to this depth. Two strings of 154mm ID uPVC casing were run into
the hole, one to 108m with a 3m sump and 4m gravel packed slotted section, and another to
22.3m with a 6m sump and 3m gravel packed slotted section. A 4m cement plug was placed
at 95m to isolate the loser aquifer. The purpose of running the two strings was twofold, both
for investigation and to monitor the effect of pumping RN29295 on both aquifer systems. The
deep bore yielded 5l/s, pH 6.7, EC 45μS, standing water level approximately 56m. The
-shallow bore yielded 0.5l/s, pH 7.9, EC 128μS, standing water level approximately 10.5m.

RN29295

RN29295 was drilled in the same manner to and approximately 30m north of RN29294 for
production purposes between 29/7/94 and 6/7/94. A total depth of 126m was drilled and
logged. The hole was cased to 103m with 154mm ID Fibreglass Reinforced Plastic (FRP)
casing, with 6m of stainless steel in line screens from 103m and a 3m stainless steel sump to
112m. The screens were sand packed with graded and washed silica quartz, and the aquifer
isolated with a 6m concrete sump. The bore airlifted 5L/s, pH 6.3, EC 30μS, standing water
level approximately 55m.

RN29296

The shallow sites were chosen to intersect the aquifer discovered in RN29292. RN29296 was
drilled 35m towards Ranku from RN29292 to a depth of 26.2m between 8/7/94 and 9/7/94
and the bore was logged to this depth. Drilling methods were the same as for RN29295, with
FRP casing to 19m, followed by screens to 23m and a stainless steel sump to 26m. Airlift
yield was 0.5L/s and standing water level 14.3m.
RN29297 was drilled 35m from RN29292 away from Ranku to a depth of 27m between 10/7/94 and 12/7/94. The bore was logged to total depth. Drilling methods were the same as for RN29296, with FRP casing to 18.5m, followed by screens to 22.5m and a stainless steel sump to 25.5m. Airlift yield was 0.7L/s and standing water level approximately 14.5m.
### TABLE A2  BORE LITHOLOGICAL DESCRIPTIONS

| RN 29290 | 0-2m       | CLAY, very slightly sandy (fine), orange, lateritic ironstone nodules (pebble sized, rounded). |
|          | 2-12m      | CLAY, white grey mottled Fe orange, semi plastic, slightly moist. Minor very fine sand to small pebble sized ironstone nodules throughout, water and foam injection from 10m. Becoming bleached to pure light grey clay by 11m, with 5-10% ironstone chips and nodules. |
|          | 12-36m     | CLAY/MUD, dark grey, stiff and smooth, plastic, no ironstone or sand, minor thin beds of indurated claystone, buff. |
|          | 36-84m     | SANDSTONE, very fine, silty clayey, weathered, Fe stained, white-yellow. Indurated 41-42m, unconsol after. seepage water <1L/s. Sub rounded, fine to very fine, mod sorted, Fe cemented, quartzitic, minor feldspar, ironstone, lithic, and calcareous or clayey concretions. |

| RN 29291 | 0-5m       | SILTY LOAM, lateritic clayey soil, orange-red, pebble sized ironstone concretions |
|          | 5-7.5m     | SILTY SAND, loose, fine-medium grained, sub-rounded quartzitic, ferruginous, orange-red. |
|          | 7.5-24m    | SANDY CLAY, silty, fine quartzitic, rounded, weakly iron cemented, wet at 18m, becoming orange with occasional hard sandstone bands due to extra iron cementation. Approx 0.5L/s 18-21m, dirty water, (5" airlift). |
|          | 24-26m     | CLAY, orange and purple mottled white clay, smooth, plastic. |
|          | 26-38m     | SANDSTONE, poorly iron cemented, orange, fine-very fine quartzose with hard beds as per 7.5-24m. Occasional mica flecks. 0.25L/s discharge increase at 44-45m. Indurated iron cemented sandstone layer as above at45-46m. |
|          | 38-78m     | MUDSTONE/CLAY, (slightly sandy, fine quartz), smooth, very plastic, dark grey, extremely contaminated with uphole sediments, possibly interbedded mudstone and sandstone layers as above. |

| RN 29292 | 0-5m       | SILTY LOAM, lateritic clayey soil, orange-red, pebble sized ironstone concretions |
|          | 5-8m       | SILTY SAND, loose, fine-medium grained, sub-rounded quartzitic, ferruginous, orange-red. |
|          | 8-23m      | SANDY CLAY, silty, fine quartzitic, rounded, weakly iron cemented, wet at 18m, becoming orange with occasional hard sandstone bands due to extra iron cementation. |
|          | 23-35m     | CLAY, orange and purple mottled white clay, smooth, plastic. |
|          | 35-48.4m   | MUDSTONE/CLAY, (slightly sandy, fine quartz), smooth, very plastic, dark grey, with light grey thin claystone layers throughout. |
RN29293

0-5m SILTY LOAM, lateritic clayey soil, orange-red, pebble sized ironstone concretions
5-17m SANDY CLAY, silty, yellow, fine-very fine, poorly cemented, quartzose, sub rounded, wet at 5m, with red-brown harder bands due to iron cementation, up to 20% of sample. Becoming more clayey by 12m, yellow-white, minor sand content.
17-35m CLAY, purple, white and yellow, very minor fine sand, smooth, plastic, very orange 34-35m.
35-87m CLAY/MUD. Dark grey, very plastic, occasional thin beds of indurated faunal claystone (decreasing with depth).
87-126m MUDSTONE, indurated but still soft, slaty cleavage, dark grey, with 10-20% clayey SANDSTONE, % increasing with depth, yellow-white, very clayey, very fine, quartzose, rising to 20-30% by 105m. Large sand content in drilling fluid indicates sandstone % greater than in cuttings.

RN29294

0-7m SILTY LOAM, lateritic clayey soil 0 - 3.5m, orange-red, pebble sized lateritic ironstone concretions 3.5 - 7m.
7-20m SANDY CLAY, very fine, sub rounded quartzitic, very clayey/silty, minor glauconite and opaques, yellow white, occasional iron cemented indurated layers.
20-33m CLAY, purple, white and orange mottled, very minor fine sand, smooth, semi plastic.
33-97m CLAY/MUD, Dark grey, very plastic, occasional thin orange beds of indurated claystone/sandstone.
97-114m MUDSTONE, as above but with 30% clayey SANDSTONE, yellow-white, very clayey, very fine, quartzose, with minor opaques esp iron pyrite.

RN29295

0-7m SILTY LOAM, lateritic clayey soil, orange-red, pebble sized lateritic ironstone concretions throughout.
7-18m SANDY CLAY, very fine, sub rounded quartzitic, very clayey/silty, minor glauconite and opaques, yellow white, occasional iron cemented indurated layers.
18-39m CLAY, purple, white and orange mottled, very minor fine sand, smooth, semi plastic.
39-96m CLAY/MUD, Dark grey, very plastic, occasional thin buff orange beds of indurated claystone/sandstone.
96-126m MUDSTONE, as above but with 30% clayey SANDSTONE, yellow-white, very clayey, very fine, quartzose, with minor opaques.

RN 29296

0-6m SILTY LOAM, lateritic clayey soil, orange-red, pebble sized ironstone concretions
6-24m SANDY CLAY, moderately silty, fine-very fine quartzitic, rounded, weakly iron cemented, with occasional hard sandstone bands due to extra iron cementation, yellow brown.
24-27m CLAY, orange brown and purple mottled white clay, smooth, semi-plastic, minor fine sand, perhaps contamination.
RN 29297

0-8m  SILTY LOAM, lateritic clayey soil, orange-red, pebble sized ironstone concretions

8-22.5m  SANDY CLAY, moderately silty, fine-very fine quartzitic, rounded, weakly iron cemented, with occasional hard sandstone bands due to extra iron cementation, yellow brown.

24-27m  CLAY, orange brown and purple mottled white clay, smooth, semi-plastic, minor fine sand, perhaps contamination.
### Depth Bore Graphic

<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>BORE CONSTRUCTION LOG</th>
<th>STRATA DESCRIPTION</th>
<th>AQUIFERS (WATER STRUCK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>203mm diameter hole backfilled</td>
<td>CLAY: minor fine sand, orange, abundant vateritic ironstone nodules.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>CLAY: semi-plastic, moist, minor fine-very fine sand, orange and purple mottled.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>MUD: smooth, plastic, dark grey, minor thin interbeds of indurated buff claystone.</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>SANDY CLAY: very fine, silty, moderately well sorted, sub-rounded, quartzitic with minor opaques, white-yellow.</td>
<td>Approx. 1 L/s Airlift</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>SWL +5.2m 27-5-94</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>110</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**COMPOSITE LOG OF BORE 29290**

**Fig. A2(a)**
<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>BORE CONSTRUCTION LOG</th>
<th>STRATA DESCRIPTION</th>
<th>AQUIFERS (WATER STRUCK)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CLAYEY SOIL: lateritic, orange-red.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SANDY CLAY: moderately silty, fine-very fine, rounded, quartzitic with minor opaques and glauconite, occasional ferruginous bands, yellow-orange.</td>
<td>0.5 L/s</td>
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<tr>
<td></td>
<td></td>
<td>CLAY: smooth, semi-plastic, minor fine sand, white with orange and purple mottling.</td>
<td>0.25 L/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MUD: smooth, plastic, dark grey, minor fine-very fine sand, occasional thin buff claystone interbeds.</td>
<td>0.75 L/s</td>
</tr>
</tbody>
</table>

**COMPOSITE LOG OF BORE 29291**

Fig. A2(b)
DEPTH BORE GRAPHIC STRATA AQUIFERS

CONSTRUCTION LOG DESCRIPTION (WATER STRUCK)

Q,5m ;

CLAYEY SOIL: lateritic, orange-red.

SANDY CLAY: moderately silty, fine-very fine, rounded, quartzitic with minor opaques, occasional poorly iron cemented bands, yellow-orange.

CLAY: smooth, semi plastic, minor fine sand, white with orange, purple and brown mottling.

MUD: smooth, plastic, minor fine sand, dark grey with occasional thin buff claystone interbeds.

COMPOSITE LOG OF BORE 29292

Fig. A2(c)
**DEPT BORE GRAPHIC**

**CONSTRUCTION LOG**

**STRATA DESCRIPTION**

**AQUIFERS (WATER STRUCK)**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Bore Graphic</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5m</td>
<td>104mm ID PVC Casing</td>
<td></td>
</tr>
<tr>
<td>10m</td>
<td>203mm ID Steel Casing</td>
<td>Clays: smooth, semi-plastic, minor fine sand, white with purple, yellow and brown mottle.</td>
</tr>
<tr>
<td>20m</td>
<td>Backfill</td>
<td></td>
</tr>
<tr>
<td>30m</td>
<td>Backfill</td>
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</tr>
<tr>
<td>40m</td>
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<td>60m</td>
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<td>70m</td>
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<td>100m</td>
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<tr>
<td>110m</td>
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<tr>
<td>120m</td>
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<td></td>
</tr>
<tr>
<td>140m</td>
<td>Backfill</td>
<td></td>
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</table>

**COARSE MOW RIVER GRAVEL**

**CLAYEY SOIL:** Lateritic, orange-red

**SANDY CLAY:** Moderately silty, fine-very fine, sub-rounded quartzite, occasional poorly iron cemented bands, yellow-brown.

**CLAY:** Smooth, semi-plastic, minor fine sand, white with purple, yellow and brown mottle.

**MUD:** Plastic, smooth, dark grey with occasional thin beds of buff claystone.

**MUD:** As above but semi-indurated (consistency of chocolate) with 20-30% clayey sand content, very fine quartzose, yellow-white.

**SWL 47m 9-6-94**

**3 L/s**

**COMPOSITE LOG OF BORE 29293**

*Fig. A2(d)*
CLAYEY SOIL: lateritic, orange-red.
SANDY CLAY: very fine, sub rounded, minor opaques and glauconite, occasional iron cemented bands.
CLAY: semi plastic, smooth, rare fine sand, white with purple and orange mottling.
MUD: plastic, dark grey, thin occasional bands of buff siltstone.
MUD: as above with 30% clayey sand, very fine, sub rounded quartzitic with minor opaques including iron pyrite, white-yellow.
CLAYEY SOIL: lateritic, orange-red.

SANDY CLAY: very fine, sub rounded, minor opaques and glauconite, occasional iron cemented band.

CLAY: semi plastic, smooth, rare fine sand, white with purple and orange mottling.

MUD: plastic, dark grey, occasional bands of buff siltstone.

MUD: as above with approximately 30% clayey sand, very fine, quartzitic with minor opaques, white-yellow.
CLAYEY SOIL: lateritic, orange-red.

SANDY CLAY: moderately silty, fine-very fine, rounded quartzitic with minor opaques, occasional poorly iron cemented bands, yellow-brown.

CLAY: smooth, semi-plastic, minor fine sand, white with purple and brown mottling.

Fig. A2(g)
<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>BORE CONSTRUCTION LOG</th>
<th>GRAPHIC STRATA</th>
<th>AQUIFERS (WATER STRUCK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5m</td>
<td>Cement</td>
<td>CLAYEY SOIL: latitic, orange-red.</td>
<td></td>
</tr>
<tr>
<td>1.5m</td>
<td>146mm ID PVC Casing</td>
<td>SANDY CLAY: moderately silty, fine-very fine, rounded, quartzitic with minor opaques, occasional poorly iron cemented bands, yellow-brown.</td>
<td></td>
</tr>
<tr>
<td>4.5m</td>
<td>16x30 filter sand</td>
<td>CLAY: smooth, semi plastic, minor fine sand, white with purple and brown mottling.</td>
<td></td>
</tr>
</tbody>
</table>

**COMPOSITE LOG OF BORE 29297**

Fig. A2(h)
A3 Test Pumping

A total of five bores were test pumped during the investigation to determine bore and aquifer hydraulic characteristics. The shallow aquifer was tested by the pumping of 29292, 29296 and 29297, and the deep aquifer by 29293 and 29295. Tests on the bores included preliminary pumping, a step drawdown test and constant discharge test. The only exception was 29293 which had an extended step drawdown test conducted. Extra development work was carried out on 29297 in an attempt to increase the yield of the bore. This included water jetting of the screens and airlifting. The exercise provided only minimal increase in efficiency of the bore. The drawdowns before and after the development exercise are presented in Figure A3(j).

All results from the test pumping are presented in the following drawdown versus log time plots, Figures A3(a) to (k). Observation bores were monitored during the constant discharge tests for all the bores. Response in 29293 and 29294 was measured during the testing of 29295, these plots are shown in Figures A3(f) and (g). With the shallow aquifer being unconfined the limited duration of test pumping prevented any measurable response from the observation bores.
CONSTANT DISCHARGE TEST 29292

Fig. A3(b)

DISCHARGE 1.5 L/s
DATE 15-6-94
SWL 14.62 mbgl
DATE 9-6-94
SWL 46.92 mbgl

STEP DRAWDOWN TEST 29293
Fig. A3.1 (a)

DISCHARGE 4.5 L/s
DATE 8/9-7-94
SWL 55.15 mbgl

CONSTANT DISCHARGE TEST 29295

DISCHARGE 4.5 L/s
TIME (minutes)

0
0 2 4 6 8 10 12 14 16 18

DRAWDOWN (metres)

0 100 200 300

SWL 55.15 mbgl

DISCHARGE 4.5 L/s
TIME (minutes)
Fig. A3(g)

DATE  8/9-94
SWL    55.57 mbgl
PUMPED BORE  29295
DISCHARGE  4.5 L/s
RADIUS  34.4 m

CONSTANT DISCHARGE TEST 29295 -
OB 29294
DATE 11-7-94
SWL 13.85 mbgl

STEP DRAWDOWN TEST 29296
Fig. A3(l)

DISCHARGE 0.5 L/s
DATE 12-7-94
SWL 13.85 mgbf

CONSTANT DISCHARGE TEST 29296
Fig. A3(j)

DATE 13-7-94  
SWL 15.91 mbgl

DATE 16-7-94  
SWL 15.94 mbgl

STEP DRAWDOWN TEST 29297
Fig. A3(k)

DISCHARGE 0.4 L/s
DATE 13-7-94
SWL 15.91 mbgl

CONSTANT DISCHARGE TEST 29297
APPENDIX B
Sustainable Yield Calculations
Sustainable Yield Calculations for the Shallow Aquifer -

An estimate for the sustainable yield of the shallow aquifer is based on annual rainfall infiltration recharge to the system. Although data is not available for the seasonal fluctuation of the watertable which indicates the volume of annual recharge water, the figures for Milikapiti have been adopted to provide an initial estimate of the likely volume of recharge.

From the measured water level rises in the Van Diemen Sandstone aquifer and corresponding rainfall readings at Milikapiti, an infiltration rate of 13% was estimated. Applying this same infiltration rate for Wurankuwu with an assumed average rainfall of 1500 mm the volume of annual rainfall infiltration recharge to the aquifer would be of the order of 195,000 m³/sq.km. Extracted over 10 months of the year this equates to approximately 7 L/s continuous flow.

Groundwater movement from topographically high areas to low areas results in discharge from the aquifer in a radial direction via the escarpments. With a transmissivity of 50 m²/d and a gradient of 3 m in 1500 m (0.002) (from 29294 to 29292) the estimated radial flow per kilometre width would be 100 m³/d or approximately 1.2 L/s.

Therefore across one square kilometre of aquifer the nett flow of water available would be 5.8 L/s. Whilsts in theory this represents a plentiful supply, the thin and shallow nature of the aquifer combined with a low watertable makes for bore construction difficulties and a practical limit to extraction far less than the calculated 5.8 L/s.

Sustainable Yield Calculations for the Deep Aquifer -

Without a full understanding of the recharge mechanisms to the deep aquifer an estimate of the sustainable yield of the aquifer is based on limiting the cone of depression due to pumping to minimise the risk of saltwater intrusion. With the proximity to the coast a distance of 2 km from the pumping centre has been chosen at which to limit the drawdown due to pumping. As the potentiometric level in the deep aquifer is only metres above mean sea level it has been decided to limit the annual drawdown at a radius of 2 km to within 1m.

Considering the hydraulic parameters of the deep aquifer, T = 300 m²/d and S, = 0.0001, and assuming the worst case scenario of a confined aquifer -
at r = 2 km, the time at which drawdown commences, t, is determined by :-

\[ S, = 2.25Tt/r^2 \]
\[ t = S, r^2/2.25T \]
\[ t = 0.0001 \times 2000 \times 2000/2.25 \times 300 \]
\[ t = 0.59 \text{ days} = 853 \text{ minutes} \]

From 853 minutes to 525600 minutes (1 year) is approximately 3 log cycles.
Log cycle drawdown, s, is determined by :-

\[ T = 15.8Q/s \]
\[ s = 15.8Q/T \]
\[ s = 0.0527Q \]

For the drawdown at 2 km to be less than 1 m after 1 year of pumping, s < 1/3(no of log cycles).
Therefore:

\[ s = 0.0527Q < 0.333 \]
\[ \text{or} \]
\[ Q < 6 \text{ L/s} \]

Based on these calculations an estimate for the sustainable yield of the deep aquifer is 6 L/s, assuming the pumping centre is at 29295.
APPENDIX C
Bore Completion Reports - Wurankuwu
BORE COMPLETION REPORTS - WURANKUWU PRODUCTION BORES

1. INTRODUCTION

The investigation recently completed at Wurankuwu included the drilling of a total of 8 bores within 2.5km of the settlement, 5 of which have been completed as production bores. As a result of the investigations, assessments have been made for bore usage as per the accompanying bore completion reports.

2. GEOLOGY

The investigations indicate that the Tertiary Van Diemen Sandstone is present in this area, overlying sediments of the Moonkinu Member, which is described regionally as Mesozoic (Cretaceous) in age and consisting of fine to very fine sublabile sandstone interbedded with grey carbonaceous mudstone and siltstone, laid down in a shallow marine environment during a period of regressing sea (Hughes, 1976).

Three bores, RN29292, 29296, and 29297 were completed in the Van Diemen Sandstone, in conditions similar to those found at Banjo Swamp at Milikapiti. These bores yielded small supplies of groundwater. These beds varied in thickness, and consisted of sandy clays, fine to very fine, yellow-brown with occasional poorly iron cemented bands, underlain by Moonkinu Member sediments comprising approximately 15m of white clays with purple, yellow and brown mottling underlain by dark grey mudstones, with interbedded clayey sands at depth. 29295 was completed at depth in one of these clayey sand interbeds, and appears to be similar in hydrogeological environment to production bore 27923 at Milikapiti.

3. WATER QUALITY

Analysis of water from the shallow aquifer bores, 29292, 29296, and 29297, indicates that water quality is within potable water quality guidelines, however iron and low pH conditions exceed non health related limits in some cases. Water from the deep aquifer, 29295 is also within potable limits, however does display a low pH condition in excess of non health related limits. The corrosive nature of these waters is typical of tropical coastal aquifer systems, and should be taken into account when designing the reticulation system.

4. BORE PERFORMANCE

The shallow aquifer bores, 29292, 29296 and 29297 have recommended rates of 0.5, 0.4 and 0.4 L/s. The deep aquifer bores, 29294 and 29295 have recommended rates of 2 L/s each. It is recommended that the two deep aquifer bores be equipped to supply the community, as outlined in Section 4 of Report No.28/90 - "Wurankuwu Groundwater Resource Evaluation". 29295 should be utilised as the main duty bore and 29294 as the stand-by. This will provided a maximum flow of 2 L/s with 2 L/s stand-by.
WATER RESOURCES DIVISION

TEST REPORT — BORE RN. 29292

Bore Location: RANKU
Map: BATHURST ISLAND 1:100,000 Sheet: 4974
Grid Reference: 387 - 157

Client: ATSIC
Purpose: DOMESTIC

RECOMMENDATION. Pumping Rate: 0.5 L/s. Pump Setting: 25.6 m.

For alternative pumping rates or settings contact: Water Resources.
General recommendations are on the reverse side. Sasco House,
In all correspondence please quote bore RN 29292. Darwin NT.

BORE DATA.

Finished depth: 29.7 m Completion Date: 2.6.94. Test Date: 17.6.94
Standing Water Level: 14.62 m on 15.6.94. Test Rate: 1.5 L/s
Construction details:

Interval. Description.
0 - 5.5 m 203 mm ID steel casing - cemented.
0 - 29.7 m 104 mm ID class 12 PVC
17.7 - 23.7 m 104 mm ID class 12 PVC with 1 mm slots.

Notes: 1. Top of casing as constructed was 0.4 m above ground.
2. All depths are measured from natural ground level.
3. Test rates are not indicative of safe long term pumping rates.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 104 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 104 mm.

COMMENTS.

1. The above recommendations are based on a constant rate test at 1.5 L/s for
23 hrs and assume hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples while pumping
should be incorporated when equipping this bore.
3. Bore should be fitted with a pump shut-off sensor to ensure the water level
does not fall below the top of the slots.
4. Electric submersible pumps should be fitted with a shroud to prevent
overheating.
5. SWL should be monitored to ascertain seasonal variations.

WATER ANALYSIS. No 93/94/1159

Prepared by: R Setchell
2.8.94

Checked by: D.Chin
2.9.94
RECOMMENDATIONS FOR FINISHING, OPERATING AND PROTECTING GROUNDWATER BORES.

Attention to the following points will ensure a long and safe life for the bore supply and help prevent pollution of the groundwater resource.

1. Construct a concrete apron around the bore head to prevent surface flow, seepage and waste from entering the bore.

2. Seal the space between the casing and pump equipment to prevent entry of vermin, dirt and pollutants.

3. Prevent spillage of fuel and oil on the ground around the bore. Store fertilizer and other chemicals at least 50 m. away.

4. Keep stock away from the bore head. Discourage domestic activity at the bore.

5. If the bore is no longer required the casing is to be securely capped.

IN ADDITION, please ensure that the BORE IDENTIFICATION TAG is retained securely at all times. The registered bore number is Water Resources Division’s only reference to the scientific and engineering data on this bore and hence important to WRD’s further advice to bore owners.

BORE LOCATION MAP.
Assume - End of wet season SWL 14.6m BGL
- Estimated seasonal decline 0.2m/month = 2m/year

BORE PERFORMANCE CURVE 29292
WATER RESOURCES DIVISION

TEST REPORT — BORE RN. 29294

Bore Location: RANKU.
Map: BATHURST ISLAND 1:100,000 Sheet: 4974.

Client: ATSIC.
Purpose: DOMESTIC.

******************************************************************************
RECOMMENDATION. Pumping Rate: 2 L/s. Pump Setting: 70 m.
FROM STRING No 2
For alternative pumping rates or settings contact: Water Resources.
General recommendations are on the reverse side. Sasco House,
In all correspondence please quote bore RN 29294. Darwin NT.

******************************************************************************

BORE DATA.

Finished depth: 108 m. Completion Date: 29.6.94 Test Date: not tested
Standing Water Level: 55.57 m on 8.7.94. Test Rate: 
Construction Details: Test Duration: 

This bore has two[2] strings of casing installed

Interval. Description.

<table>
<thead>
<tr>
<th>String 1</th>
<th>String 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 3.0 m</td>
<td>0 - 100.5 m</td>
</tr>
<tr>
<td>13.3 - 16.3 m</td>
<td>104 mm ID Class 12 PVC casing.</td>
</tr>
<tr>
<td>16.3 - 22.3 m</td>
<td>104 mm ID Class 12 PVC casing with end cap</td>
</tr>
<tr>
<td>254 mm ID steel casing.</td>
<td>104 mm ID Class 12 PVC casing.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interval.</th>
<th>Description.</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.5 - 104.5 m</td>
<td>254 mm ID steel casing.</td>
</tr>
<tr>
<td>104 mm ID Class 12 PVC casing with 1mm slots.</td>
<td></td>
</tr>
<tr>
<td>104 mm ID Class 12 PVC casing with end cap</td>
<td></td>
</tr>
</tbody>
</table>

Notes: 1. Top of casing as constructed was 0.6 m above ground.
2. All depths are measured from natural ground level.
3. Test rates are not indicative of safe long term pumping rates.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 104 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 104 mm.

******************************************************************************
COMMENTS.

1. The above recommendations are based on the test pumping of bore RN 29295 as they both exploit the same aquifer at a similar interval. The hydraulic parameters of this bore should be determined by test pumping at the time of equipping.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when equipping this bore.

3. Monitoring of water levels and quality should be carried out as outlined in Section 4 of Report No 28/94D, "Kurranwui Groundwater Resource Evaluation."

4. Care should be taken when equipping that pump is installed in casing string No 2 by first checking depths.

******************************************************************************

WATER ANALYSIS. Not yet sampled

Prepared by: D.Chin 6.01.95
Checked by: D.Chin 6.01.95
RECOMMENDATIONS FOR FINISHING, OPERATING AND PROTECTING GROUNDWATER BORES.

Attention to the following points will ensure a long and safe life for the bore supply and help prevent pollution of the groundwater resource.

1. Construct a concrete apron around the bore head to prevent surface flow, seepage and waste from entering the bore.

2. Seal the space between the casing and pump equipment to prevent entry of vermin, dirt and pollutants.

3. Prevent spillage of fuel and oil on the ground around the bore. Store fertilizer and other chemicals at least 50 m. away.

4. Keep stock away from the bore head. Discourage domestic activity at the bore.

5. If the bore is no longer required the casing is to be securely capped.

IN ADDITION, please ensure that the BORE IDENTIFICATION TAG is retained securely at all times. The registered bore number is Water Resources Division’s only reference to the scientific and engineering data on this bore and hence important to WRD’s further advice to bore owners.

BORE LOCATION MAP.
Fig C. (g)

- Assume - End of wet season SWL 55.5m BGL
- Estimated seasonal decline 2.0m
- This bore performance curve is based on test pumping of 29296
WATER RESOURCES DIVISION

TEST REPORT — BORE RN. 29295


******************************************************************************

RECOMMENDATION. Pumping Rate: 2 L/s. Pump Setting: 70 m.

For alternative pumping rates or settings contact: Water Resources. General recommendations are on the reverse side. Sasco House, in all correspondence please quote bore RN 29295. Darwin NT.

******************************************************************************

BORE DATA.

Finished depth: 112 m. Completion Date: 6.7.94. Test Date: 9.7.94. Standing Water Level: 55.15 m on 7.7.94. Test Rate: 4.5 L/s. Test Duration: 24.5 hrs.

<table>
<thead>
<tr>
<th>Interval</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 7.0 m</td>
<td>254 mm ID steel casing.</td>
</tr>
<tr>
<td>0 - 103.0 m</td>
<td>152 mm ID fibreglass casing.</td>
</tr>
<tr>
<td>103 - 109.0 m</td>
<td>152 mm ID stainless steel screens, 0.5 mm apertures.</td>
</tr>
<tr>
<td>109 - 112.0 m</td>
<td>152 mm ID stainless steel sump.</td>
</tr>
</tbody>
</table>

Notes: 1. Top of casing as constructed was 0.8 m above ground. 2. All depths are measured from natural ground level. 3. Test rates are not indicative of safe long term pumping rates.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm. MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

******************************************************************************

COMMENTS.

1. The above recommendations are based on a constant rate test at 4.5 L/s for 24.5 hrs and a step drawdown test up to 8 L/s and assume hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when equipping this bore.

3. Monitoring of water levels and quality should be carried out as outlined in Section 4 of Report No 28/94D, "Wurankuwu Groundwater Resource Evaluation".

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WATER ANALYSIS. No 93/94/0600.

Prepared by: P Rees 26.7.94 Checked by: D Chinn 5.01.95
RECOMMENDATIONS FOR FINISHING, OPERATING AND PROTECTING GROUNDWATER BORES.

Attention to the following points will ensure a long and safe life for the bore supply and help prevent pollution of the groundwater resource.

1. Construct a concrete apron around the bore head to prevent surface flow, seepage and waste from entering the bore.

2. Seal the space between the casing and pump equipment to prevent entry of vermin, dirt and pollutants.

3. Prevent spillage of fuel and oil on the ground around the bore. Store fertilizer and other chemicals at least 50 m. away.

4. Keep stock away from the bore head. Discourage domestic activity at the bore.

5. If the bore is no longer required the casing is to be securely capped.

IN ADDITION, please ensure that the BORE IDENTIFICATION TAG is retained securely at all times. The registered bore number is Water Resources Division's only reference to the scientific and engineering data on this bore and hence important to WRD's further advice to bore owners.

BORE LOCATION MAP.
Assume - End of wet season SWL 55.1m BGL
- Estimated seasonal decline 0.2m/month = 2m/year

BORE PERFORMANCE CURVE 29295
WATER RESOURCES DIVISION

TEST REPORT — BORE RN. 29296

Bore Location: RANKU.  
Map: BATHURST ISLAND 1:100,000  

Client: ATSIC.  
Purpose: DOMESTIC.

RECOMMENDATION.  Pumping Rate: 0.4 L/s.  Pump Setting: 24 m.

For alternative pumping rates or settings contact: Water Resources.  
General recommendations are on the reverse side.  
In all correspondence please quote bore RN 29296.  Darwin NT.

BORE DATA.

Finished depth: 26.2 m.  Completion Date: 7.7.94.  Test Date: 12.7.94.  
Standing Water Level: 13.85 m on 11.7.94.  Test Rate: 0.5 L/s.  
Construction details:  

<table>
<thead>
<tr>
<th>Interval</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 3.0 m</td>
<td>254 mm ID steel casing.</td>
</tr>
<tr>
<td>0 - 19.2 m</td>
<td>152 mm ID fibreglass casing.</td>
</tr>
<tr>
<td>19.2 - 23.2 m</td>
<td>152 mm ID stainless steel screens,</td>
</tr>
<tr>
<td></td>
<td>0.5 mm apertures.</td>
</tr>
<tr>
<td>23.2 - 26.2 m</td>
<td>152 mm ID stainless steel sump.</td>
</tr>
</tbody>
</table>

Notes: 1. Top of casing as constructed was 0.3 m above ground.  
2. All depths are measured from natural ground level.  
3. Test rates are not indicative of safe long term pumping rates.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.  
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

COMMENTS.

1. The above recommendations are based on a constant rate test at 0.5 L/s for 8 hrs and assume hydrological conditions remain constant.  
2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when equipping this bore.  
3. Care should be taken when running the pump through the screens into the sump.  
4. Electric submersible pumps should be fitted with a shroud to prevent overheating.  
5. Bore should be fitted with a pump shut-off sensor to ensure the water level does not fall below the bottom of the screens.  
6. SWL should be monitored to ascertain seasonal variations.

WATER ANALYSIS.  
No 93/94/0061.

Prepared by: R. Setchell  Checked by: D. Chin  
20.7.94  2.9.94
RECOMMENDATIONS FOR FINISHING, OPERATING AND PROTECTING GROUNDWATER BORES.

Attention to the following points will ensure a long and safe life for the bore supply and help prevent pollution of the groundwater resource.

1. Construct a concrete apron around the bore head to prevent surface flow, seepage and waste from entering the bore.

2. Seal the space between the casing and pump equipment to prevent entry of vermin, dirt and pollutants.

3. Prevent spillage of fuel and oil on the ground around the bore. Store fertilizer and other chemicals at least 50 m. away.

4. Keep stock away from the bore head. Discourage domestic activity at the bore.

5. If the bore is no longer required the casing is to be securely capped.

IN ADDITION, please ensure that the BORE IDENTIFICATION TAG is retained securely at all times. The registered bore number is Water Resources Division's only reference to the scientific and engineering data on this bore and hence important to WRD's further advice to bore owners.

BORE LOCATION MAP.
Assume - End of wet season SWL 13.8m
- Estimated seasonal decline 0.2m/month = 2m/year

BORE PERFORMANCE CURVE 29296
Bore Location: RANKU.
Map: BATHURST ISLAND 1:100,000 Sheet: 4974.
Grid Reference: 368 - 170.

Client: ATSIC.
Purpose: DOMESTIC.

RECOMMENDATION.
Pumping Rate: 0.4 L/s
Pump Setting: 24 m.

For alternative pumping rates or settings contact: Water Resources.
General recommendations are on the reverse side. Sasco House,
In all correspondence please quote bore RN 29297. Darwin NT.

BORE DATA.
Finished depth: 25.5 m. Completion Date: 9.7.94.
Standing Water Level: 15.91 m on 13.7.94.
Construction details:

<table>
<thead>
<tr>
<th>Interval</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 6.0 m</td>
<td>203 mm ID steel casing.</td>
</tr>
<tr>
<td>0 - 18.5 m</td>
<td>146 mm ID class 12 PVC casing.</td>
</tr>
<tr>
<td>18.5 - 22.5 m</td>
<td>152 mm ID stainless steel screens, 0.5 mm apertures.</td>
</tr>
<tr>
<td>22.5 - 25.5 m</td>
<td>152 mm ID stainless steel sump.</td>
</tr>
</tbody>
</table>

Notes: 1. Top of casing as constructed was 0.5 m above ground.
2. All depths are measured from natural ground level.
3. Test rates are not indicative of safe long term pumping rates.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 146 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 146 mm.

COMMENTS.
1. The above recommendations are based on a constant rate test at 0.4 L/s for 20 hrs and assume hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when equipping this bore.
3. Care should be taken when running the pump through the screens into the sump.
4. Electric submersible pumps should be fitted with a shroud to prevent overheating.
5. Bore should be fitted with pump shut-off sensor to ensure the water level does not fall below the bottom of the screens.
6. SWL should be monitored to ascertain seasonal variation.

WATER ANALYSIS. No 93/94/0052
Prepared by: R Setchell
20.7.94
Checked by: D.Chin
2.9.94
RECOMMENDATIONS FOR FINISHING, OPERATING AND PROTECTING GROUNDWATER BORES.

Attention to the following points will ensure a long and safe life for the bore supply and help prevent pollution of the groundwater resource.

1. Construct a concrete apron around the bore head to prevent surface flow, seepage and waste from entering the bore.

2. Seal the space between the casing and pump equipment to prevent entry of vermin, dirt and pollutants.

3. Prevent spillage of fuel and oil on the ground around the bore. Store fertilizer and other chemicals at least 50 m. away.

4. Keep stock away from the bore head. Discourage domestic activity at the bore.

5. If the bore is no longer required the casing is to be securely capped.

IN ADDITION, please ensure that the BORE IDENTIFICATION TAG is retained securely at all times. The registered bore number is Water Resources Division's only reference to the scientific and engineering data on this bore and hence important to WRD’s further advice to bore owners.

BORE LOCATION MAP.
Assumed - End of wet season SWL 15.6m BGL
- Estimated seasonal decline 0.2m/month = 2m/year

BORE PERFORMANCE CURVE 29297