CONTENTS

1. INTRODUCTION
2. GEOLOGY OF THE AREA
3. SURVEY AIMS
4. INSTRUMENTATION
5. FIELD TECHNIQUE
6. INTERPRETATION
7. RESULTS
1. INTRODUCTION

In early June of 1984, a small seismic survey was carried out at Yarralin by members of the Geophysics Section, Water Division. It was undertaken in order to provide data that would assist in directing the Yarralin Groundwater Investigation which was already underway at the time of the survey. A total of twenty-four man days was devoted to gathering data and travelling to and from the investigation site from Darwin. In all, 7.08 km of seismic profiling were completed using 120 m spread lengths and a 10 m geophone interval throughout, with no spread overlap.
2. GEOLOGY OF THE AREA

All seismic data was taken within 1.7 km of the Wickham River on the recent alluvial sediments of its floodplain. The composition of these sediments varies from the fine, loamy material comprising the near subsurface, to the silts, sands and gravels sometimes found further down. Water, when encountered, flows from sand and gravel bands of up to 3 metres thickness which, if present, either directly overlie, or are within 5 metres of bedrock. Hence these sand and gravel bands comprise the aquifer over the area, and the Yarralin Groundwater Investigation aimed to locate and tap this aquifer where it is deepest, to allow maximum drawdown.

Underlying these alluvial deposits is the Bynoe Formation of interbedded reddish brown and greyish green dolomitic siltstones.
3. SURVEY AIMS

The aim of the survey was to gather data which would allow a prediction of bedrock depth and its variation to be made over a number of lines selected by the officer in charge of the Yarralin Groundwater Investigation. Given the geological conditions, it is unlikely that any geophysical measurement would be capable of predicting the presence or absence of the aquifer at any location, and certainly not its depth. However the rationale for monitoring bedrock depth was to minimise the risk of drilling an unsatisfactory hole by at least ensuring that if a hole did intersect the aquifer, the latter would be deep enough to accommodate the necessary drawdown, as the aquifer is never too far from bedrock, as is mentioned above.
4. INSTRUMENTATION

An SIE RS4 12 channel seismic recording unit was employed to amplify and record the geophone signals. In these units, the output from each of the 12 amplifiers drives a galvanometer upon which is placed a mirror which deflects a beam of light onto a moving dry photographic film; timing marks at 10 msec intervals are recorded simultaneously. Using this system, an event can be timed to within 1 msec; however reading errors can be greater than this at large shotpoint-geophone distances because of rounding of the first breaks due to the attenuation of the high frequency components of the transmitted seismic waves.

The unit includes a capacitor-discharge firing circuit with which the explosives are detonated; a time break is recorded on a 13th trace on the photographic paper to which all arrival times are referenced.
5. FIELD TECHNIQUE

As the request for geophysical work was received only two weeks before the programmed end of the drilling phase of the Yarralin Groundwater Investigation, it was necessary that data be gathered and interpreted rapidly. Hence it was decided to use 12 geophone intervals per spread instead of the usual 24, and to sacrifice spread overlap for the sake of speed of coverage.

Each spread was thus made up of 12 geophone intervals of 10 m length, and hence 13 geophone positions, including those at either end. For each spread, shots were fired from either end into the spread, with the closest geophone occupying the second geophone position 10 m away from the shot, and with the farthest geophone at the other shotpoint 120 m away. As the geophone cable possesses 13 takeouts wired with takeouts 1 and 13 in parallel, the above arrangement of shot and geophones could be maintained while shooting from either end of the spread, by removing the geophone at the current shotpoint end and placing it at the opposite shotpoint. Note that adjacent spreads shared a common shotpoint.

All holes were drilled with a one-man power auger to a maximum depth of 0.8 m. Submarine electric detonators and AN60 gelignite comprised the explosive source; no more than three 25 mm sticks were ever required per shot, as this charge yielded sufficient energy for sharp breaks to be recorded at geophone distances of up to 120 m.

All lines were flagged on a compass bearing prior to taking seismic measurements; distances were measured in the course of profiling and are expected to be accurate to within 1%. A labelled star picket was emplaced at the beginning and the end of each line. The lines were not levelled in order to save time.

Fig 1. shows the locations of the seismic lines.
6. INTERPRETATION

The data was interpreted on a spread by spread basis using the "intercept time method"; corrections were then made for charge depth. As the lines were shot with no spread overlap, a "reciprocal time method" interpretation could not yield continuous depth coverage, with less coverage, and sometimes none at all, as depths (and hydrogeological interest) become greater, due to the increasing critical distances under these conditions. Hence such an interpretation was not carried out.*

Plates 1 and 2 present the interpreted sections. It is important that these diagrams be understood properly; hence a brief description of their method of construction follows.

An "intercept time method" interpretation assumes that the depth variation of bedrock over the length of a spread is linear. Spread travel times are divided into those refracted from different layers, and each such set of plotted times is fitted with a straight line, which is where the linear depth variation assumption is enforced. The intercept of this line on the time axis is then read, and from it is calculated the depth that such a linear refractor would have if it continued past the critical distance (the distance at which rays from the refractor become the first arrivals) to just beneath the shotpoint. Hence the depth calculated in this manner is that which the best approximation linear refractor, as judged by linearizing times beyond the critical distance, would possess if extrapolated to the shotpoint. At each shotpoint two such depths are calculated - one for the spread on either side of it. In Plates 1 and 2 these depths are plotted beneath a point half way between the shotpoint and the critical distance for that layer.

Hence the sections of Plates 1 and 2 are incapable of representing detail in bedrock depth variations. The bedrock is represented by a series of straight lines which may be understood as representing a linearization of bedrock depth variations over their length, and thus represents the changes in bedrock depth in broad terms only. Note also that these sections are to be viewed as graphs of bedrock depth rather than elevation, as no surface levelling was carried out and hence the surface is represented as a straight line at zero depth.

Also shown on Plates 1 and 2 are the abbreviated geological logs of those holes which are situated on the seismic lines.

* As a deepening of bedrock would have to be broad enough for there to be sufficient storage in the aquifer to make extraction of water from it worthwhile, the loss of resolution incurred through being prevented from making a "reciprocal time method" interpretation is not as worrisome as it would be under other conditions.
7. RESULTS

The sections show that most of the area can be represented by three subsurface layers - an upper layer with velocities in the range 290 m/s to 470 m/s, a second layer whose velocities range from 820 m/s to 1930 m/s, and a third layer whose velocity varies between 2850 m/s and 4570 m/s. However, parts of the lines show only two layers viz 180 m N to 380 m N on Line 1, 500 m S to 720 m S on Line 2, and 1040 m W to 1360 m W on Line 4. At these locations the second layer has a velocity in the range 2260 m/s to 3030 m/s which is intermediate between the second and third layer velocities of the more normal three layer case. These two-layer areas are shown in the line location plan of Fig 1.

Comparison of the geological logs with the depth sections shows that whereas the third seismic layer depth and the depth to fresh siltstone are often nearly coincident (at RN 22735, RN 22796, RN 22795 and RN 22764) the fresh siltstone depth is also sometimes underestimated (at RN 22765, RN 22797, RN 22820, RN 22799, RN 22736 and RN 22793). In all cases of the bedrock depth being underestimated, the error is probably attributable to the operation of the "hidden layer problem" so prevalent in seismic refraction interpretation. In all but one of the above cases of underestimation, the second layer velocity is at the low end of its range (less than 1100 m/s), and as the velocity of the sediments is expected to increase with depth, especially at depths below the water table (which is at about 15 m throughout the survey area), these velocities, which were measured for waves travelling horizontally through the upper section of the layer, are an underestimate of the velocities of waves travelling vertically through the entire layer on their way to the refractor beneath; and these higher velocities from deeper down are not reflected in the surface-measured travel times. As the former, lower, velocities are used in bedrock depth calculations, these depths are also underestimated.

Hence where the second layer velocities are 1500 m/s or above, the data show that bedrock depth estimates are good. Where the second layer velocities are recorded as below this, they are probably underestimated for the layer as a whole and the bedrock depth with them. The degree of underestimation for a particular velocity can be judged from a comparison of drillhole and seismic data presented in the plates.

Without actually drilling on the sites, it is impossible to establish a geological explanation for the lateral changes from three layers into two on Lines 1, 2 and 4. The velocity of the second layer is intermediate between that of alluvium and that of fresh bedrock, and hence may represent either compacted alluvium or weathered bedrock.