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RESISTIVITY IMAGING AND BOREHOLE INVESTIGATION OF THE BANTING AREA AQUIFER, SELANGOR, MALAYSIA

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Rapid industrialization in Selangor has increased the demand for water in recent years. Two-dimensional resistivity imaging surveys were carried out as part of a groundwater study in the Banting area, Selangor. Four lines were established at nearby boreholes for comparison. The primary goal of this survey is to delineate the thickness of the aquifer and depth to bedrock. The result of the resistivity imaging shows that aquifer thickness is about 10 to 30 m, and in some exceptional cases up to 45 m depending on the thickness of all deposits, as well as the nature of the bedrock. The depth of bedrock varies from 30 m up to 65 m. The resulting resistivity images from these surveys were matched with borehole and geological information provided by the Geological Survey of Malaysia.

INTRODUCTION

Banting, Selangor, is one of the most important agricultural areas in Malaysia. Recently, this region has become steadily more and more industrialized. An increasing number of industries, together with untrusion of sea water has lead to increased stress on groundwater supplies. The groundwater resource is likely to be one of the important sources of water supply in the future.

An intensive search for water resources has been carried out in the western part of Selangor. The Geological Survey of Malaysia has carried out an extensive drilling program for the delineation of aquifers in the Banting area. The data obtained by this program have made it possible to compare borehole data with recent 2-D resistivity imaging, and to evaluate the applicability of 2-D resistivity imaging methods for delineation of groundwater in the Banting area.

The application of geophysical methods to study groundwater is now commonplace in the hydrogeological community. Of these methods, the electrical imaging survey is a relatively new geophysical technique for environmental surveys (Griffiths and Barker, 1993). It is a tool that can delineate the groundwater aquifer boundary between the clay and sandy layers, and between formations bearing fresh water and dry layers or impervious bedrock.

This study focuses on mapping of an aquifer in the Banting area. The aquifer is made up of unconsolidated sand and pebble deposits of the Quaternary age that occur along the Sungai Langat River. The aim of this study is to delineate the thickness of an aquifer and depth to bedrock using 2D-resistivity imaging.

GEOLOGY OF THE AREA

The area is made up of Quaternary alluvium emplaced on top of sandstone and shale of the Kenny Hill Formation (bedrock). Four units are recognized in the Quaternary alluvium; namely the Beruas Formation, Gula Formation, Kempadang Formation, and Simpang Formation. The uppermost layer is the Beruas Formation consisting of Holocene terrestrial sediments of brownish color.

Underlying the Beruas Formation is the Gula Formation. It is comprised of clay, silt, and sand with shells. The presence of the Gula Formation acts as an impermeable layer, thus confining other formations beneath it.

The Kempadang Formation lies beneath the Gula Formation. This formation grades from clay to silt and fine sand from top to bottom, and resembles the materials of Beruas Formation. The similarity in composition of Kempadang and Beruas Formation has made formation differentiation difficult for most drillers and loggers.

The lowermost alluvial unit is the Simpang Formation. It consists of terrestrial Pleistocene deposits made up largely of sand and gravel with minor clay content. It overlies the Kenny Hill Formation bedrock. Coarse to very coarse sand and gravel occurs as the main component at the base of the formation.

HYDROGEOLOGY

The gravel and sand deposits of the coastal alluvium in Malaysia represent the most important aquifers in the country, with vast quantities of water in groundwater storage. The development of considerable amounts of groundwater through high capacity wells is possible. The presence of unconsolidated sand and gravel layers in Selangor was recognized by miners and geologists since the beginning of the search for tin deposits in the alluvium, probably more than 100 years ago. However the importance of the sand and gravel deposits as groundwater aquifers was not recognized. As the demand for fresh water has increased in Selangor, the attention of many hydrogeologists and geophysicists turned to exploration of the gravel and sand alluvium for groundwater.

Based on lithological data from the geologic logs, the sandy aquifer in the Banting area was delineated. This aquifer is made of inter-layering coarse sandstones, gravels, and pebbles, and based on these characteristics, it has been interpreted as ancient Langat river basin deposits. Although the aquifer is generally unconfined, locally semiconfined conditions exist due to the presence of sandy and silty clay interlayers.

Generally, the groundwater from the alluvium is suitable to be used as a source for drinking and industrial uses. Rapid development in Selangor is threatening the quality of the groundwater, especially as a result of sea water intrusion.

RESISTIVITY IMAGING SURVEY

Electrical imaging is a surveying technique for an area of complex geology where the use of resistivity sounding and other techniques are unsuitable for providing detailed subsurface information in a limited area (Barker, 1999).

Geoelectrical imaging surveys are normally carried out with multi-electrode resistivity systems (Figure 1). Such surveys use a number of electrodes (25 to 100) deployed in a straight line with constant spacing, connected to a multicore cable. A computer-controlled system (Griffiths, et al., 1990) is used to select the active electrodes for inverse resistivity section. Each electrode is set up automatically. The data gathered in these surveys are interpreted using an inexpensive microcomputer to provide an inverse resistivity section.

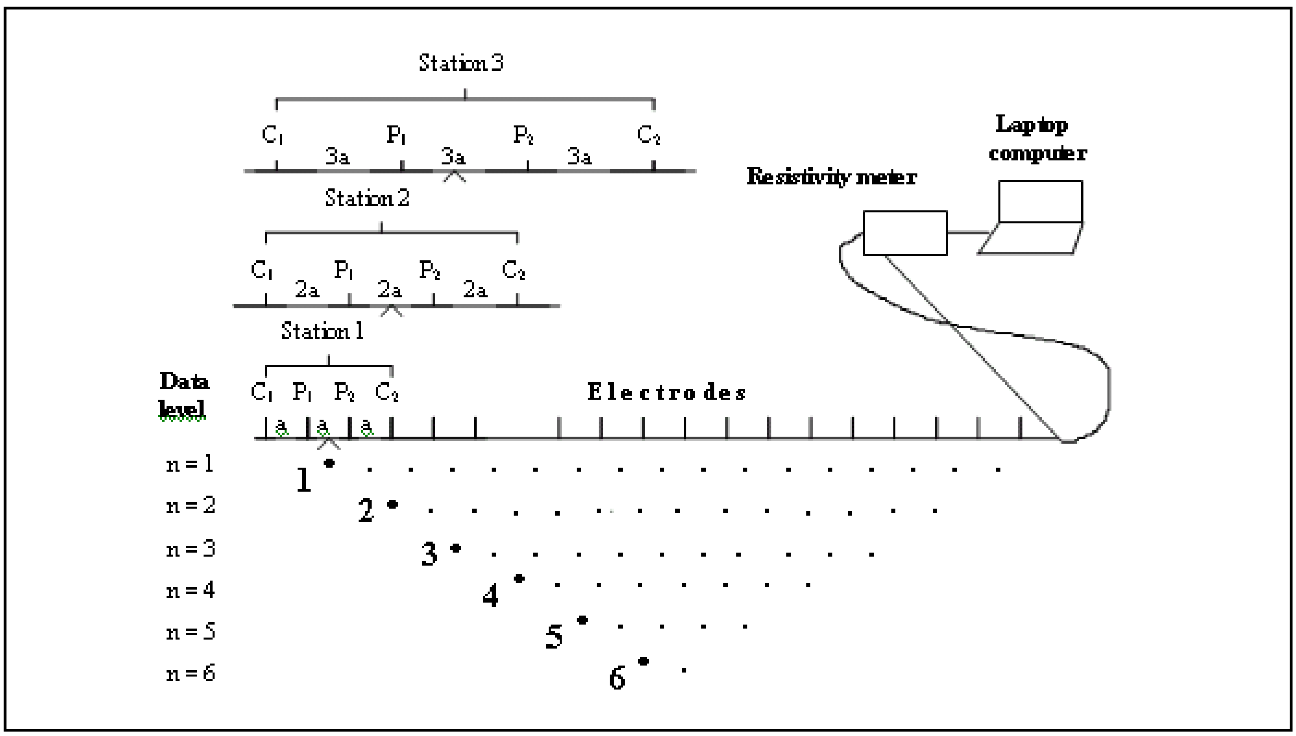

Figure 1. The arrangement of electrodes for a 2-D electrical survey and the sequence of measurement used to build up a pseudosection.

FIELD DATA ACQUISITION

With the development of the multi-electrode resistivity array, the collection of 2-D resistivity data is becoming increasingly popular for hydrogeological studies (Griffiths and Barker, 1993) because of its ability to delineate different subsurface geological formations, and its ability to distinguish between fresh water and dry layers.

The 2-D resistivity surveys were performed at the proposed sites using the Terrameter SAS 4000 resistivity meters and multicore cable to which electrodes were connected at takeouts molded at predetermined equal intervals. The well-known Wenner method of electrode configuration was applied in the study area. The Wenner array gives a clear image of groundwater boundaries as horizontal structures, and gives reliable results.

DISCUSSION AND RESULTS

Four resistivity lines were conducted near borehole 21 as shown in Figure 2.

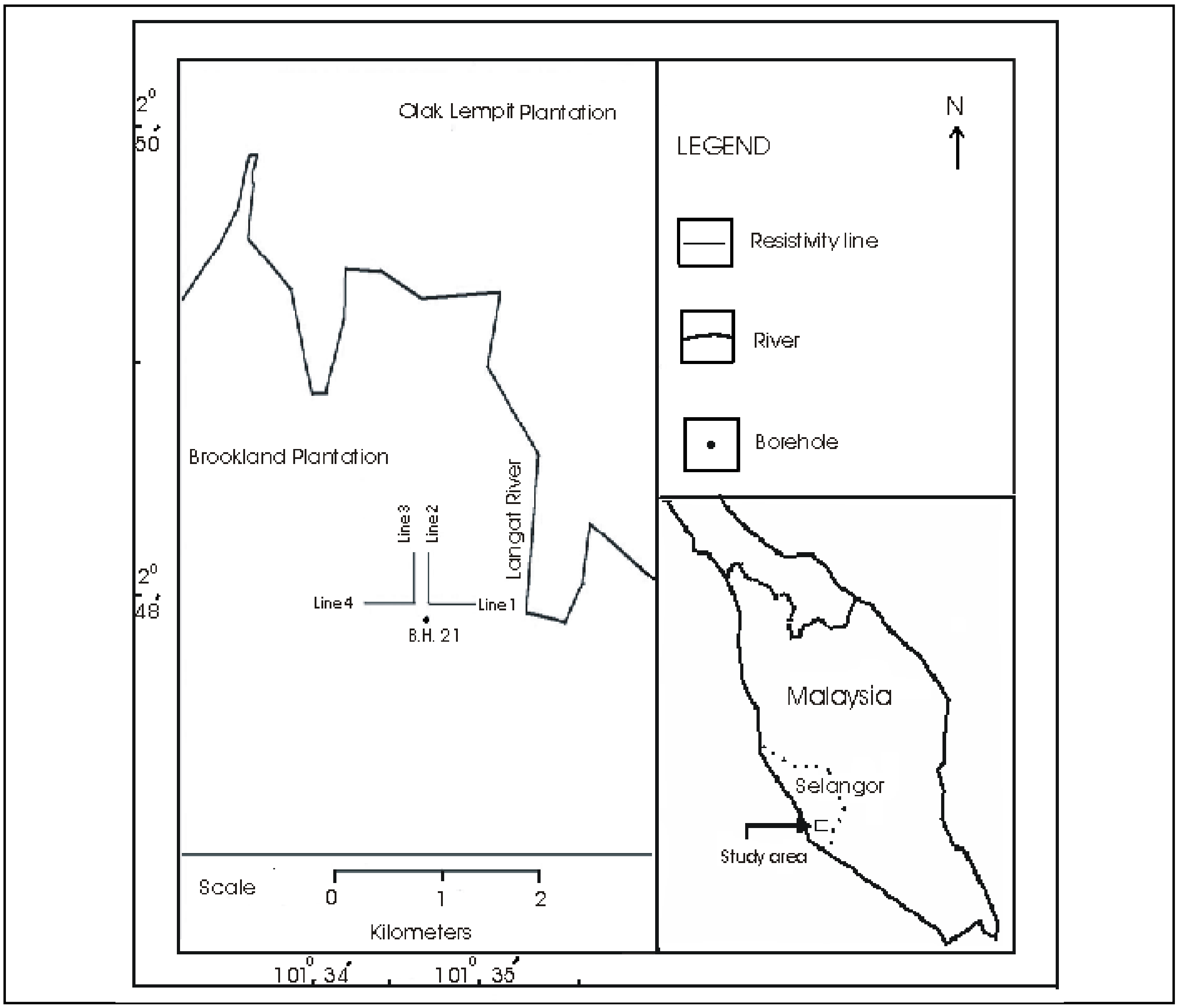

Figure 2. Schematic sketch of survey area showing resistitivity lines in survey.

The reason for concentrating our survey in this area is to make a comparison between the information on subsurface geology obtained from borehole 21 (Figure 3), and the information obtained from 2-D electrode imaging. Total lengths of all lines are 400 m.

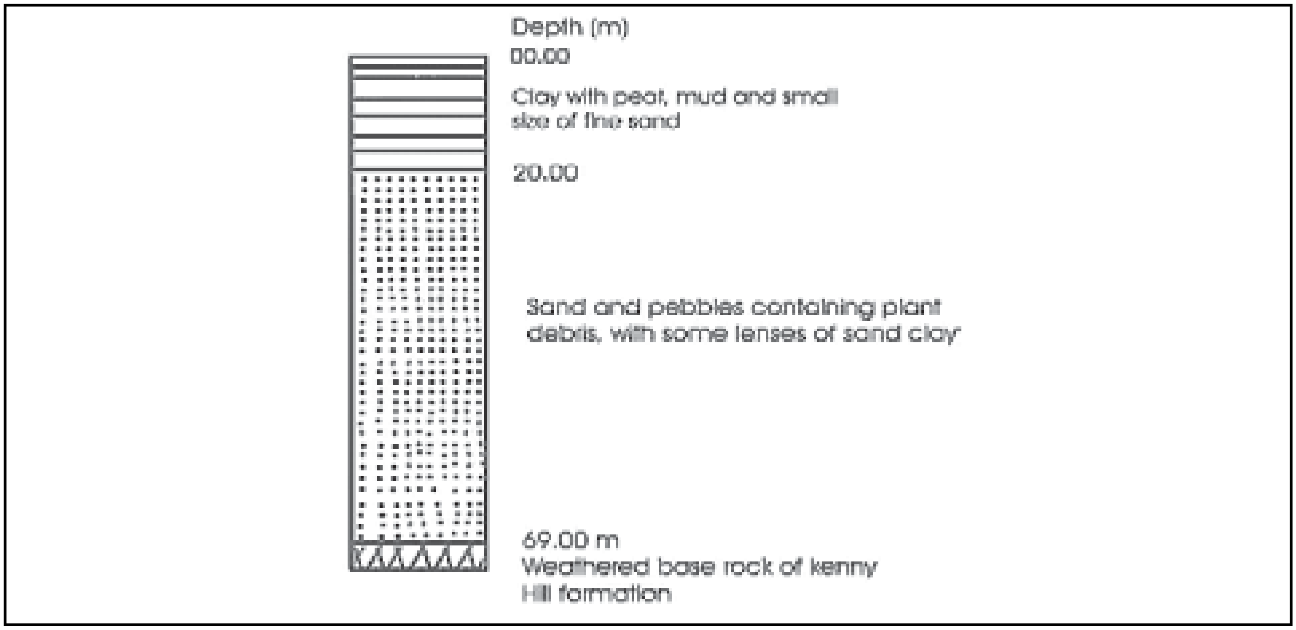

Figure 3. The lithological log of the B.H.-21 located near the survey area.

All of the images show the upper part of the section is dominated by low resistivity, and that resistivity increases with depth. The interpretation of these lines is based on the borehole informations showing that the subsurface material in this area can be delineated into three main units, which are bedrock of the Kenny Hill Formation, the sandy aquifer of the Simpang Formation, and an undefined clay, which contains peat and lenses of fine sand.

Line 1 (Figure 4) is the nearest line to borehole 21. Taking the information from borehole 21 as a control (reference), we can draw the boundary between three main units, namely Kenny Hill

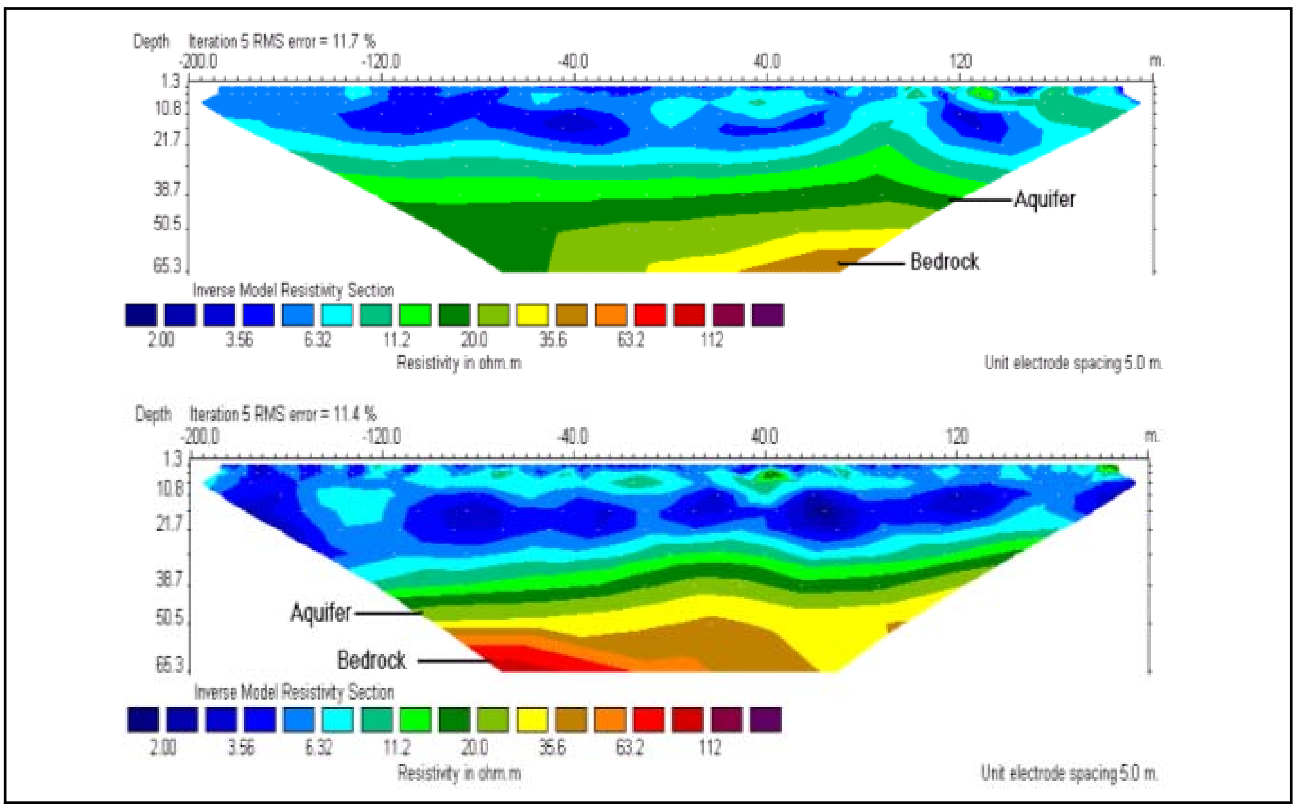

Figure 4. Resistivity inverse model section of (a) line 1 and (b) line 2.

Formation (bedrock), Simpang Formation (aquifer) and clay. From the borehole information, the depth of the bedrock is approximately 69 meters. Matching the resistivity value with the approximate depth, the bedrock resistivity value is about 35.6 ohm/m. Considering the blue region (resistivity less than 11.2 ohm-m) as the clay layer, a line can be drawn on the resistivity image of Line 1. At the borehole location, this line is drawn at about 21 meters depth. This is quite consistent with the borehole information, where the depth of the clay is 0-20 meters. The region between 11.2 ohm-m and 20.0 ohm-m is considered the aquifer (the Simpang Formation).

Comparing Line 2 and Line 4 (Figure 5) shows interesting features of a high resistivity zone within a blue region. This is probably due to lenses of sandy material deposited within the clay.

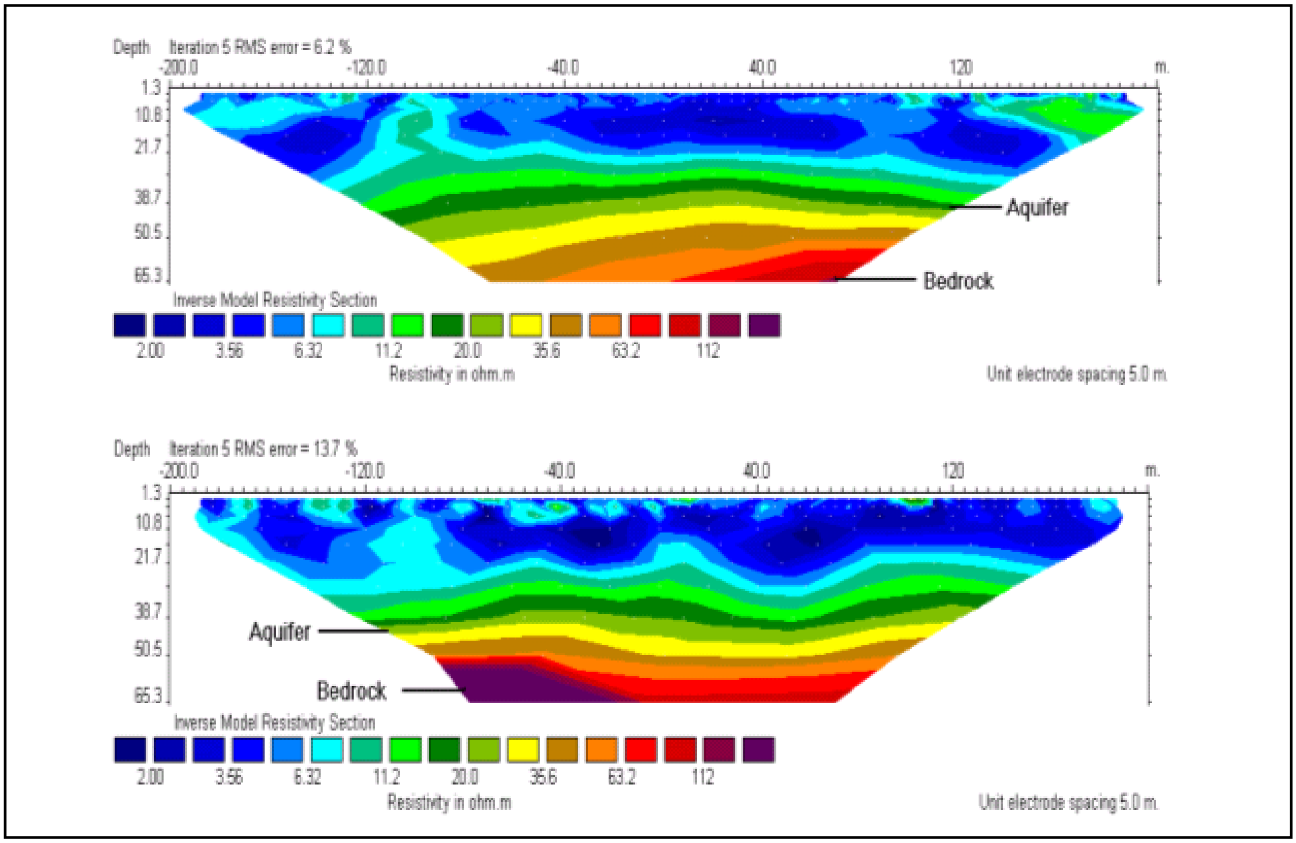

Figure 5. Resistivity inverse model section of (c) line 3 and (d) line 4.

CONCLUSION

The resistivity imaging is effective for delineating the groundwater aquifer boundary at this location. It is also effective for mapping bedrock. The interpretation clearly shows the thickness of the aquifer varies between 10 to 30 m, and in some areas up to 45 m depending on the thickness of all the deposits as well as the nature of the bedrock (fracture zone). The depth to bedrock estimated from 2-D resistivity imaging generally varies from 30 m to 65 m. The result of the resistivity imaging shows that the interpretation is accurate when compared to reference well logs.

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