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Determination of The Position and Depth of Aquifers in The Kobakma District of Central Mamberamo District

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ABSTRACT

Groundwater availability in aquifers is crucial for sustaining human settlements, particularly in Kobakma District, Central Mamberamo Regency, where clean water distribution faces significant challenges due to seasonal fluctuations and infrastructure limitations. The lack of groundwater utilization has resulted in local communities relying on rainwater as their primary water source, highlighting the necessity to identify potential groundwater sources. This research aims to determine the position and depth of aquifers in Kobakma District using the geoelectric resistivity method. By identifying subsurface conditions and geological formations, the study seeks to map groundwater availability and provide recommendations for sustainable water resource management in the region. The study employs the geoelectric resistivity method using the Schlumberger configuration to measure subsurface resistivity. Data collection was conducted across 13 test points within Kobakma District. The collected resistivity values were analyzed to interpret subsurface lithology and identify potential aquifer zones. The study primarily focuses on detecting free and confined aquifers, considering variations in rock formations, permeability, and groundwater flow dynamics. The results indicate the presence of two primary aquifer layers: a free aquifer distributed across various locations at depths ranging from 10–60 meters and a confined aquifer found at depths between 100–300 meters. Some test points showed aquifer leakage due to fault structures, influencing groundwater movement. The findings suggest that groundwater sources in the study area are unevenly distributed, requiring site-specific extraction strategies. The study provides an aquifer depth distribution map, offering critical insights for future groundwater management and well-drillin.

Introduction

The distribution of clean water in Kobakma City is gravitational with water sources coming from the Grobes River and Kali Satu River with construction starting in 2020 and 2021. The condition of the pipeline network during the rainy season can flow water to the settlements, but in the dry season the flow does not reach the settlements due to the reduced flow discharge. Intake buildings and clean water networks that can no longer function properly due to reduced river water discharge and non-technical problems such as blockages and cutting of distribution pipes. There is no clean water service in Central Mamberamo Regency, most people in Kobakma Regency only use rainwater to meet their living needs due to the water source that is far from community settlements. So this study was carried out to determine the position and depth of the aquifer in order to utilize the potential of groundwater in the city of Kobakma. Water is divided into two classifications, namely surface groundwater and subsurface groundwater. Surface groundwater is water that is on the surface of the earth in the form of rivers, lakes, etc. Subsurface groundwater is groundwater that occupies cavities in rock layers or geological formations such as underground rivers, well water etc. Subsurface groundwater can be found in water-saturated layers or aquifers.

Groundwater is dynamic and influenced by a number of natural factors. Geology and geomorphology greatly determine the prospects of the soil in an area. The geological structure affects the direction of groundwater movement, the type and thickness of the aquifer. The stratigraphy of several rock layers can affect the type, depth, and thickness of the aquifer. Meanwhile, the permeability and concentration of dissolved ions are affected by the lithology of the aquifer. The morphology of the earth's surface relief affects the occurrence and direction of groundwater movement. Changes in surface topography affect the depth of the groundwater table and the direction of groundwater movement. Morphogenesis affects permeability, porosity, and infiltration rate. Regional studies of the above aspects provide an overview of the potential of aquifers in an area.

The resistivity method is one of the geophysical methods used to determine the aquifer layer by utilizing the electrical properties of rocks. Groundwater under the surface interacts with the soil layer in the form of sand as an aquifer for groundwater. To find out the type of soil layer that groundwater passes through under the surface, measurements are carried out using the geoelectric method. The resistivity geoelectric method in this study uses a wenner configuration where this method is the main method used to find water content based on the parameters of different resistivity distributions.

The purpose of this study is to determine the position and depth of the aquifer in Kobakma District, Central Mamberamo Regency, so that the location of the groundwater aquifer and the depth of the aquifer in Kobakma District, Central Mamberamo Regency can be obtained.

Method

This study is an estimate of the aquifer layer in Kobakma District, Central Mamberamo Regency. Geophysical instrument used in resistivity studies in detecting water potential The geophysical instrument used in resistivity studies in groundwater potential detection is the AGR-300HT3 type unit. This instrument has received soil IS certification as an AGR-300HT3 type unit. This instrument has received ISO-9001 and CE O-9001 and CE certifications. This instrument has a frequency domain so that the frequency domain so that it can reach k can reach a deep depth of up to 800 m. In this study it only detects up to a depth of 200m to know up to 800 m. In this study, it only detects up to a depth of 300m to determine the thickness and position of the aquifer so that it can provide recommendations for drilling locations.

The resistivity method is one of the groups of geoelectric methods used to study the subsurface state by studying the nature of electricity flow in rocks below the earth's surface (Souisa et al., 2018). The resistivity method is used for survey of rock minerals, soil movements (landslides), seawater intrusion, liquid or solid waste, geothermal energy, geological sites and so on (Cornforth, 2004). The resistivity method is generally used for shallow exploration, about 300 – 500 m. The principle in this method is that electric current is injected into the earth through two current electrodes, while the potential difference that occurs is measured through two potential electrodes. In actual geoelectric measurements, the medium is not homogeneous with arbitrary resistivity distribution. In fact, the earth is a layered medium with each layer having a different resistivity value (Cornforth, 2004), (Souisa et al., 2016).

In determining the type of lithology based on the resistivity value, it is not based on the classification that has been explained earlier, but for the determination using lithological data obtained in the field by paying attention to the texture of the rock, whether the type of rock has strong conductor properties or weak conductor properties, in this case the rock texture that has excellent porosity and permeability can store water and water has strong conductor properties. From the combination of primary and secondary data obtained, it is used as a reference for determining the type of lithology in each layer. The reciprocity value is used to analyze the type of lithology below the surface, which is then used as a basis for determining the existence of a spring source (aquifer).

Results and Discussion

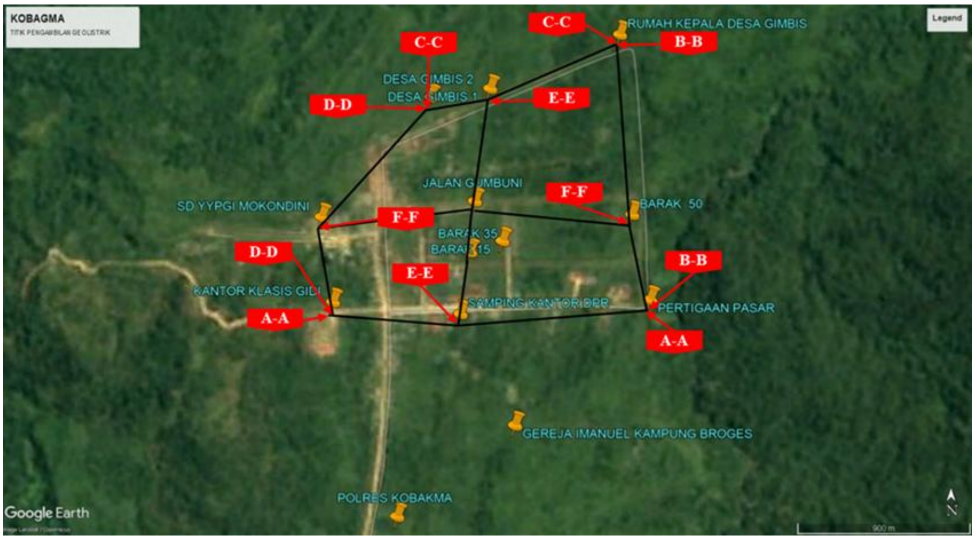


Figure 1. Layout of the Long Section Geoelectric in Central Mamberamo Regency

Geoelectric testing locations in Central Mamberamo Regency are spread across Kobakma District with a total of 13 test points. The distribution of the pick-up locations can be seen in Table 1. Based on the resistance data obtained from the results of geoelectric tests, it is possible to predict the type of material below the ground surface.

Table 1. Geopower Recap of Central Mamberamo Regency

NO	LOCATION	COORDINATE				
		B1		B2		ELEVASI
1	Barracks 15 Staff Housing	03˚ 04’ 08,7”	139˚ 04’ 08,7”	03˚ 04’ 08,7”	139˚ 04’ 08,7”	987 m
2	House of Representatives Office	03˚ 40’ 14,2”	139˚ 04’ 01,6”	03˚ 40’ 14,2”	139˚ 04’ 01,6”	995 m
3	Kobakma Market T-junction	03˚ 04’ 33,7”	139˚ 40’ 11,7”	03˚ 04’ 33,7”	139˚ 40’ 11,7”	974 m
4	Barracks 50 Staff Housing	03˚ 39’ 57,0”	139˚ 04’ 30,8”	03˚ 39’ 57,0”	139˚ 04’ 30,8”	969 m
5	Gimbis Village Head's House	03˚ 39’ 25,5”	139˚ 04’ 28,7”	03˚ 39’ 25,5”	139˚ 04’ 28,7”	922 m
6	Gimbis Village Residents' House	03˚ 39’ 35,0”	139˚ 04’ 06,6”	03˚ 39’ 35,0”	139˚ 04’ 06,6”	941 m
7	Gimbis Village	03˚ 39’ 36,6”	139˚ 03’ 56,5”	03˚ 39’ 36,6”	139˚ 03’ 56,5”	951 m
8	YPPGI Elementary School Mokondini Village	03˚ 39’ 57,4”	139˚ 03’ 38,1”	03˚ 39’ 57,4”	139˚ 03’ 38,1”	973 m
9	Gidi Classis Office	03˚ 40’ 12,1”	139˚ 03’ 40,0”	03˚ 40’ 12,1”	139˚ 03’ 40,0”	993 m
10	Barracks Housing 35	03˚ 40’ 03,4”	139˚ 04’ 03,2”	03˚ 40’ 03,4”	139˚ 04’ 03,2”	978 m
11	Gereja Imanuel I Broges	03˚ 40’ 33,4”	139˚ 04’ 10,8”	03˚ 40’ 33,4”	139˚ 04’ 10,8”	1004 m
12	Kobagma Police Station	03˚ 40’ 49,1”	139˚ 03’ 50,9”	03˚ 40’ 49,1”	139˚ 03’ 50,9”	1034 m
13	Gumbuni Street, Gimbis Village	03˚ 39’ 54,6”	139˚ 04’ 04,1”	03˚ 39’ 54,6”	139˚ 04’ 04,1”	967 m

Figure 2. Layout of Geoelectric Measurement Locations in Central Mamberamo Regency

Results of Interpretation of Geological Data

Geoelectric Data Interpretation this data analysis is interpreted from several field analysis data in a geoelectric cross-section. The results of this interpretation are presented in the form of a cross-section of type resistance, and a geoelectric interpretation of type resistance, as well as a map of the slip plane analysis of the subsurface lithological arrangement at the measurement site. To determine the lithology of the rocks on the trajectory, the interpretation of the attached data is carried out as follows:

1. Barracks Staff Housing

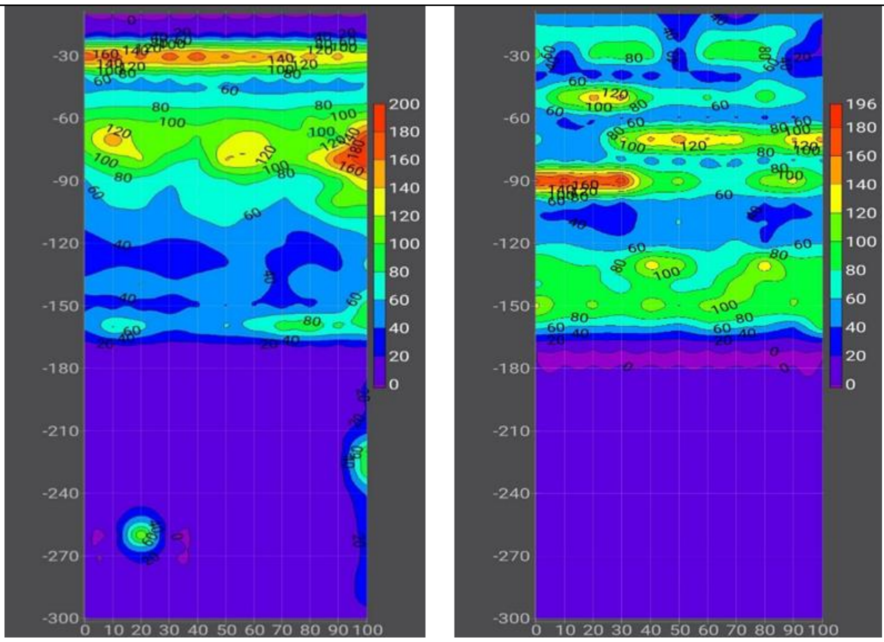


Figure 3. Spanning Pieces B1 and B2

The acquisition of Stretches 1 and 2 based on the results of geoelectric testing in the barracks staff housing produced subsurface data as shown in the figure above. In stretch 1 there is a free aquifer with a small volume. Depressed aquifers can be found at depths of ± 160 – 300 m.

Table 2. Interpretation of Stretch B1 Barracks Staff Housing 15

No.	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	POSISI AKUIFER
1	Lapisan Atas	0 - 25 m	Endapan Alluvial kerikil,pasir,dan selipan lanau lempung	
2	Lapisan-01	25 - 55 m	Lanau Pasiran	
3	Lapisan-02	55 - 110 m	Breksi Rekahan Bercampur Pasir	
4	Lapisan-03	110 - 160 m	Breksi Reekahan Rendah - Sedang	
5	Lapisan-04	160 - 300 m	Breksi Rekahan Sedang - Tinggi	

Table 3. Interpretation of Stretch B2 Barracks Staff Housing 15

No.	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	POSISI AKUIFER
1	Lapisan Atas	0 - 120 m	Endapan Alluvial kerikil,pasir,dan selipan lanau lempung	
2	Lapisan-01	120 - 160 m	Breksi Rekahan Bercampur Pasir	
3	Lapisan-02	160 - 170 m	Breksi Rekahan Sedang - Tinggi	
4	Lapisan-03	170 - 300 m	Breksi Reekahan Rendah - Sedang	

2. House of Representatives Office

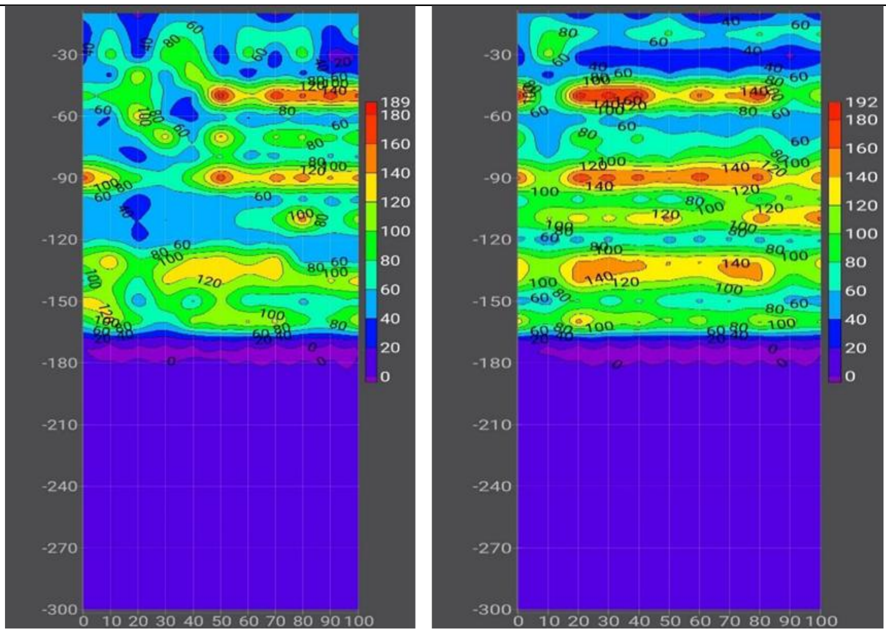


Figure 4. Spanning Pieces B1 and B2

Based on the results of geoelectric testing at the DPR office, the acquisition of Spans 1 and 2 produced subsurface data as shown in figure 4. At the point of the study location, no free aquifers or surface water were found on either stretch. Depressed aquifers are found at depths of 160 – 300 m.

Table 4. Interpretation of the B1 Layout of the House of Representatives Office

No.	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	POSISI AKUIFER
1	Lapisan Atas	0 - 120 m	Endapan Alluvial kerikil,pasir,dan selipan lanau lempung	
2	Lapisan-01	120 -160 m	Breksi Rekahan Bercampur Pasir	
3	Lapisan-02	160 - 170 m	Breksi Rekahan Sedang - Tinggi	
4	Lapisan-03	170 - 300 m	Breksi Reekahan Rendah - Sedang	

Table 5. Interpretation of the B2 Layout of the House of Representatives Office

No.	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	POSISI AKUIFER
1	Lapisan Atas	0 - 40 m	Endapan Alluvial kerikil,pasir,dan selipan lanau lempung	
2	Lapisan-01	40 - 60 m	Lanau Pasiran	
3	Lapisan-02	60 - 80 m	Breksi Rekahan Bercampur Pasir	
4	Lapisan-03	80 - 160 m	Endapan Alluvial kerikil,pasir,dan selipan lanau lempung	
5	Lapisan-04	160 - 175 m	Breksi Reekahan Rendah - Sedang	
6	Lapisan-05	175 - 300 m	Breksi Reekahan Rendah - Sedang	

3. Kobakma Market

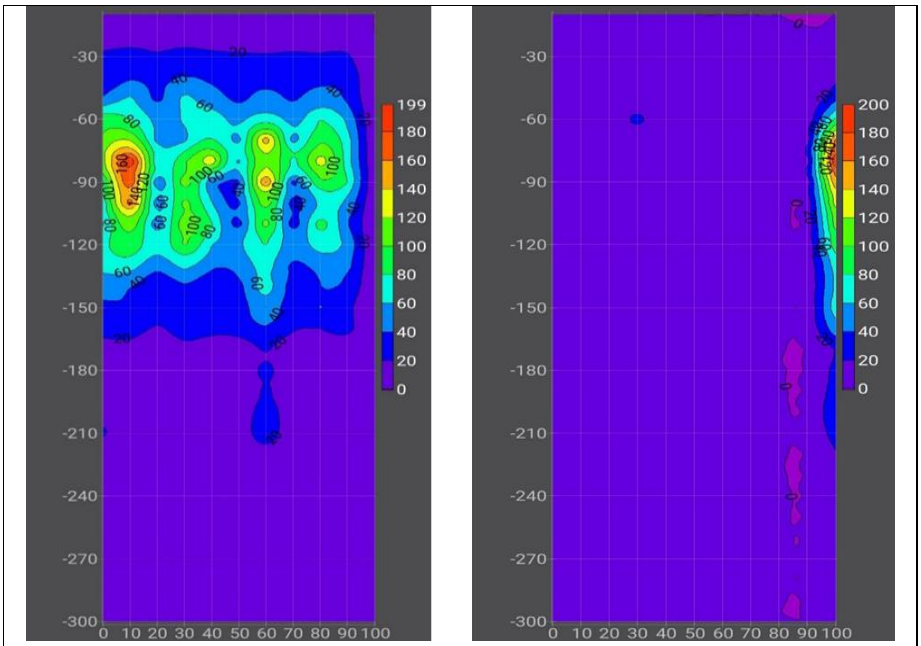


Figure 5. Spanning Pieces B1 and B2

The acquisition of B1 and B2 at Kobakma's market point produces subsurface data as shown in figure 5. Both stretches show that the aquifer is leaking so that water flows from the shallow/free aquifer layer to the depressed aquifer layer. The aquifer leak is thought to be due to the presence of fault structures acting on the span.

Table 6. Interpretation of B1 Kobakma Market

No.	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	POSISI AKUIFER
1	Lapisan Atas	0 - 60 m	Breksi Reekahan Rendah - Sedang	
2	Lapisan-01	60 -120 m	Breksi Rekahan Bercampur Pasir	
3	Lapisan-02	120 - 160 m	Breksi Rekahan Sedang - Tinggi	
4	Lapisan-03	160 - 300 m	Breksi Reekahan Rendah - Sedang	

Table 7. Interpretation of B2 Stretch of Kobakma Market

No.	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	POSISI AKUIFER
1	Lapisan Atas	0 - 65 m	Breksi Rekahan Sedang - Tinggi	
2	Lapisan-01	65 - 90 m	Lempung Kelanauan	
3	Lapisan-02	90 - 170 m	Breksi Rekahan Sedang - Tinggi	
4	Lapisan-03	170 - 300 m	Breksi Reekahan Rendah - Sedang	

4. Staff Housing

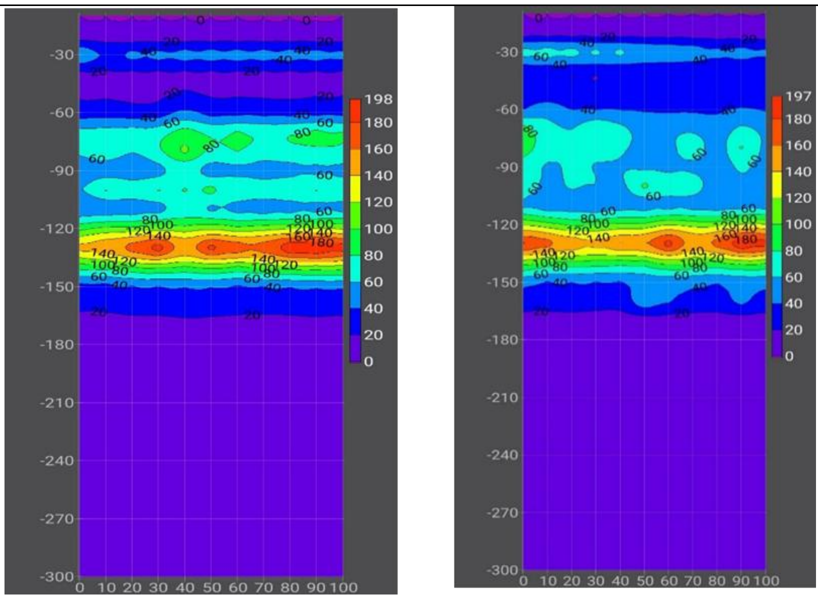


Figure 6. Spanning Pieces B1 and B2

Acquisition of a stretch at the point of Staff Housing produces subsurface data as shown in Figure 6. Free aquifers spread along a stretch with a depth of ± 0 – 25, free aquifers are infiltration from surface water such as rainwater or river water. The depressed aquifer layer of stretch 1 is at a depth of ± 35 – 55 m, while the depressed aquifer of stretch 2 is at a depth of 170 – 300. In stretch 1, deep aquifers were also found at a depth of 160 – 300 m. Among the aquifers there are watertight separation rocks.

Table 8. Interpretation of B1 Stretch of Staff Housing

No.	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	POSISI AKUIFER
1	Lapisan Atas	0 - 65 m	Breksi Rekahan Sedang - Tinggi	
2	Lapisan-01	65 -120 m	Breksi Rekahan Bercampur Pasir	
3	Lapisan-02	120 - 130 m	Lempung Kelanauan	
4	Lapisan-03	130 - 160 m	Kerikil Bercampur Pasir	
5	Lapisan-04	160 - 300 m	Breksi Reekahan Rendah - Sedang	

Table 9. Interpretation of B2 Stretch of Staff Housing

No.	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	POSISI AKUIFER
1	Lapisan Atas	0 - 60 m	Endapan Alluvial kerikil,pasir,dan selipan lanau lempung	
2	Lapisan-01	60 - 120 m	Breksi Rekahan Bercampur Pasir	
3	Lapisan-02	120 - 130 m	Lempung Kelanauan	
4	Lapisan-03	130 - 165 m	Kerikil Bercampur Pasir	
5	Lapisan-04	170 - 300 m	Breksi Reekahan Rendah - Sedang	

5. Village Head Housing

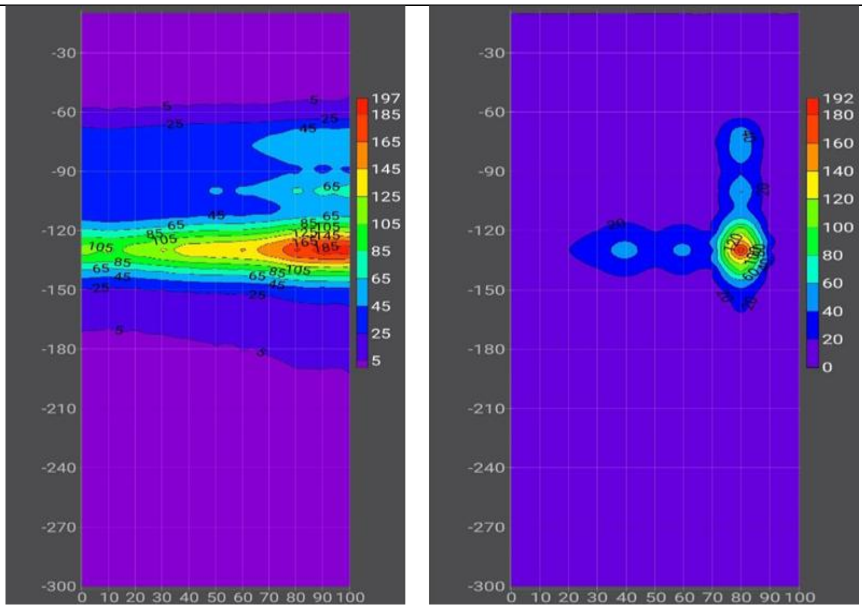


Figure 7. Spanning Pieces B1 and B2

The aquifer is free to spread along stretch 1 with a depth of 0 – 60 m. The depressed aquifer is located at a depth of 175 – 300 m. Between the free aquifer and the depressed aquifer there is a watertight separation rock. The span of 2 aquifers is leaking so that water flows from the free aquifer or surface water until the aquifer is depressed.

Table 10. Interpretation of B1 Stretch of Housing

No.	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	POSISI AKUIFER
1	Lapisan Atas	0 - 125 m	Endapan Alluvial kerikil,pasir,dan selipan lanau lempung	
2	Lapisan-01	125 - 135 m	Lempung Kelanauan	
3	Lapisan-02	135 - 150 m	Kerikil Bercampur Pasir	
4	Lapisan-03	150 - 190 m	Breksi Rekahan Sedang - Tinggi	
5	Lapisan-04	190 - 300 m	Breksi Reekahan Rendah - Sedang	

Table 11. Interpretation of B1 Landscape of Kedes Housing

No.	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	POSISI AKUIFER
1	Lapisan Atas	0 - 125 m	Breksi Rekahan Sedang - Tinggi	
2	Lapisan-01	125 - 135 m	Lempung Kelanauan	
3	Lapisan-02	135 - 160 m	Breksi Rekahan Sedang - Tinggi	
4	Lapisan-03	160 - 300 m	Breksi Reekahan Rendah - Sedang	

Based on the results of data interpretation, a summary of the position of the aquifer in Central Mamberamo Regency was obtained as attached in the following Table 12.

Table 12. Recap of Aquifer Position in Central Mamberamo Regency

NO	LOCATION	COORDINATE					DEPTH ESTIMATE		
		B1		B2		ELEVATE	Surface Water	Impermeable Zone	Aquifer
1	Barracks 15 Staff Housing	03˚ 04’ 08,7”	139˚ 04’ 08,7”	03˚ 04’ 08,7”	139˚ 04’ 08,7”	987 m	-	120-160 m	170-270 m
2	House of Representatives Office	03˚ 40’ 14,2”	139˚ 04’ 01,6”	03˚ 40’ 14,2”	139˚ 04’ 01,6”	995 m	-	120-150m	170-270 m
3	Kobakma Market T-junction	03˚ 04’ 33,7”	139˚ 40’ 11,7”	03˚ 04’ 33,7”	139˚ 40’ 11,7”	974 m	10-60 m	-	-
4	Barracks 50 Staff Housing	03˚ 39’ 57,0”	139˚ 04’ 30,8”	03˚ 39’ 57,0”	139˚ 04’ 30,8”	969 m	10-30 m	120-150 m	150-270 m
5	Gimbis Village Head's House	03˚ 39’ 25,5”	139˚ 04’ 28,7”	03˚ 39’ 25,5”	139˚ 04’ 28,7”	922 m	10-120 m	120-140 m	150-270 m
6	Gimbis Village Residents' House	03˚ 39’ 35,0”	139˚ 04’ 06,6”	03˚ 39’ 35,0”	139˚ 04’ 06,6”	941 m	10-120 m	-	140-270 m
7	Gimbis Village	03˚ 39’ 36,6”	139˚ 03’ 56,5”	03˚ 39’ 36,6”	139˚ 03’ 56,5”	951 m	10-40 m	40-90 m	180-270 m
8	YPPGI Elementary School Mokondini Village	03˚ 39’ 57,4”	139˚ 03’ 38,1”	03˚ 39’ 57,4”	139˚ 03’ 38,1”	973 m	10-60 m	-	160-270 m
9	Gidi Classis Office	03˚ 40’ 12,1”	139˚ 03’ 40,0”	03˚ 40’ 12,1”	139˚ 03’ 40,0”	993 m	10-60 m	-	180-270 m
10	Barracks Housing 35	03˚ 40’ 03,4”	139˚ 04’ 03,2”	03˚ 40’ 03,4”	139˚ 04’ 03,2”	978 m	10-30 m	-	180-270 m
11	Gereja Imanuel I Broges	03˚ 40’ 33,4”	139˚ 04’ 10,8”	03˚ 40’ 33,4”	139˚ 04’ 10,8”	1004 m	10-40 m	50-80 m	100-270 m
12	Kobagma Police Station	03˚ 40’ 49,1”	139˚ 03’ 50,9”	03˚ 40’ 49,1”	139˚ 03’ 50,9”	1034 m	10-60 m	120-150 m	160-270 m
13	Gumbuni Street, Gimbis Village	03˚ 39’ 54,6”	139˚ 04’ 04,1”	03˚ 39’ 54,6”	139˚ 04’ 04,1”	967 m	-	90-160 m	180-270 m

The results of geoelectric measurements, lithology analysis and resistivity values, show that the presence of groundwater sources in the study area is divided into 2 aquifers. The first layer is a free aquifer and the second layer is a depressed aquifer. The distribution of aquifers is not evenly distributed throughout the study area, such as at the point of Staff Housing barracks stretch 2, DPR Office in both stretches there are no free aquifers, and point Jl. Gumbuni Gimbis Village. The availability of surface groundwater in Barracks 35 Housing, YPPGI Elementary School, Gimbis Village Housing, Kepdes Housing and Kobakma Market is quite high where in the area there are groundwater sources from the groundwater table to a depth of ± 300m.

Aquifer Depth Distribution Map

The approximate position of the aquifer, its depth and distribution can be identified based on the resistance data from the geoelectric test. The method is carried out by combining several data from the results of geolysis testing so as to produce a cut of the longitudinal direction of the underground section from the location being reviewed. The longitudinal cut is made and adjusted to the direction of taking geoelectric data (B1 and B2) in accordance with the data from the geoelectric test in the previous discussion, which can be seen in the layout and longitudinal cut of the geoelectric. The distribution of groundwater surface depth was carried out using groundwater depth data for each test point (data analysis results) and using *the Inverse Distance Weighted (IDW) method* with the help of the ArcGis auxiliary program.

The data obtained in the field are the location of the measurement points, the elevation of the groundwater level in two measurements, the difference in the elevation of the groundwater level from the results of the geoelectric survey. Based on two measurement surveys conducted at the research site, there were differences in groundwater level elevation values. This is due to differences in hydrological conditions in each measurement survey. High rain intensity and long rain duration will result in an increase in groundwater level elevation. This event is part of the hydrological cycle, where groundwater is replenished from rainwater that enters the soil. The data table of survey results at the research site which contains the groundwater level elevation is superimposed with the Survey Location Area Map, so as to produce a map of the distribution of measurement points. In this study, the shape of the groundwater elevation contour map (*equipotential line*) is smooth and regular, making it easier to describe. The groundwater level elevation contour map is used as the main data in making groundwater flow patterns at the research site. The groundwater flow pattern was created using a second measurement survey because the number of measurement points was greater and the contour of the groundwater level elevation spread throughout the Mamberamo Regency District. The contour map and distribution of groundwater level depth in each research site can be seen in Figure 8 and Figure 9.

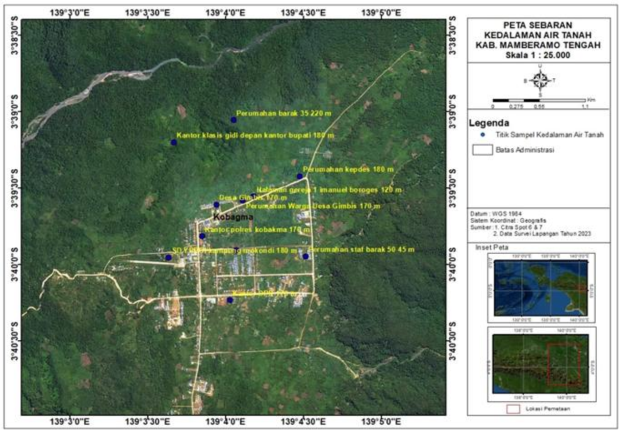


Figure 8. Map of the Central Mamberamo Groundwater Depth Observation Point

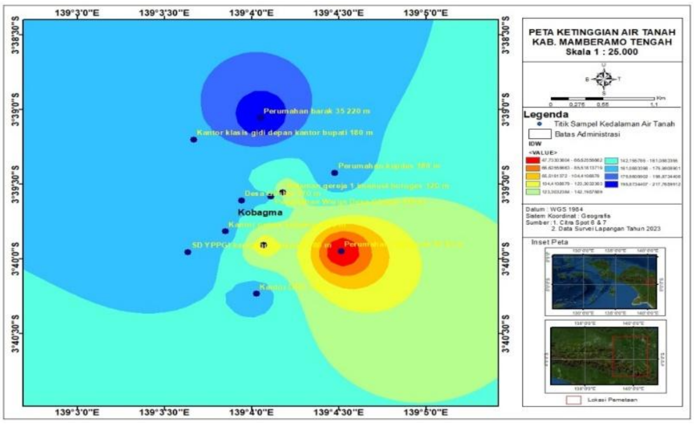
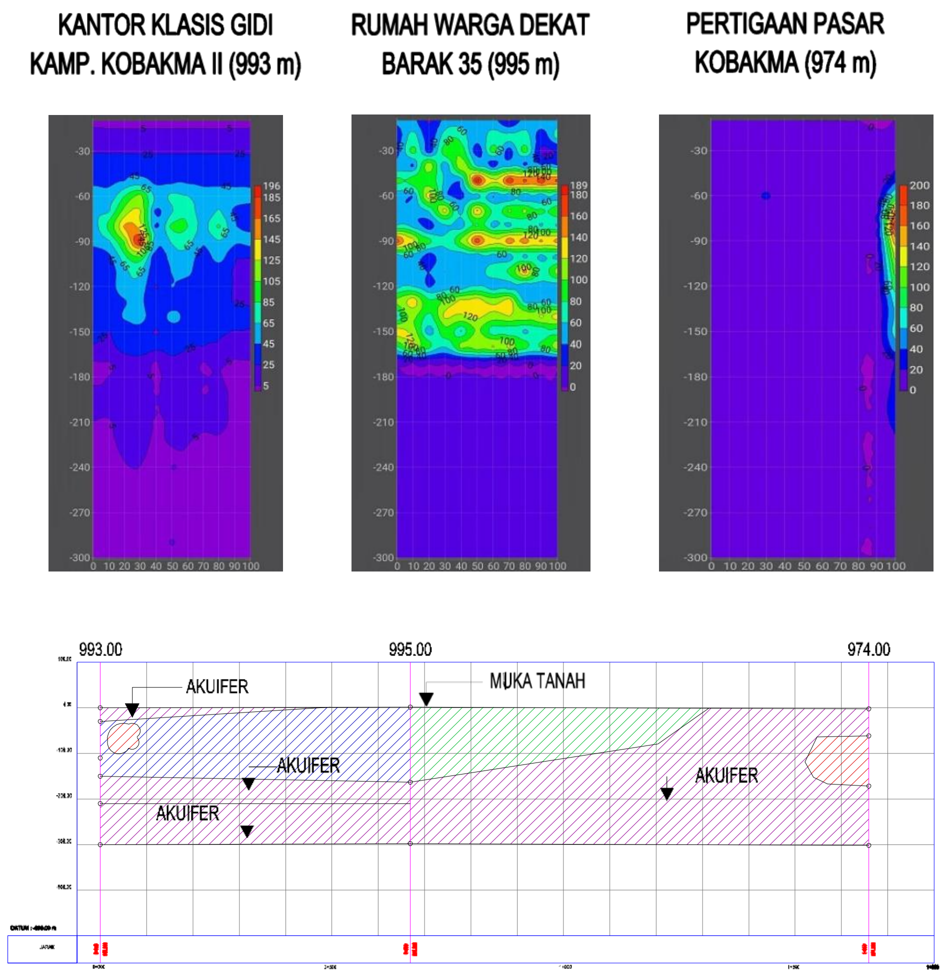


Figure 9. Map of the Distribution of Groundwater Depth in Central Mamberamo Regency

Geoelectric Elongated Pieces

The stratigraphic depiction of the subsurface soil layer in the longitudinal direction aims to obtain an overview of the location, depth and distribution of the aquifer from the study area. From the results of the depiction, it can be seen that the type of soil layer on the surface, the waterproof zone/layer which is the layer before the aquifer, the depth of the aquifer, the slope and the location of the aquifer along the longitudinal cut plane.

In general, in the research area where geoelectric surveys have been conducted, the position of the depressed aquifer is at a depth of more than 150 m below the ground level. For the future, the depth and position of the aquifer can be seen in the image of the longitudinal cut of the geoelectric test results in the research area.



POTONGAN A-A

LOKASI : KAB. MAMBERAMO TENGAH	Elvis Siep Uaga	Dr. Ir. Mujiati, S. T., M. T.	Raymond F. Hattu, S. T. NIP. 19890824 201503 1 007	SKALA : 1 : 100	HALAMAN

Conclusion

Based on the results of geoelectric measurements at the research site and lithological analysis showed that:

The position of the free aquifer is evenly distributed at each data collection point at a depth of 10 meters below the ground level with the thickness of the aquifer varying between 20 – 110 meters. Except at the point of barracks staff housing, the House of Representatives Office, and Jl. Gumbuni, Gimbis Village, no free aquifers were found. Free aquifers can be used by the community to make shallow wells and utilize groundwater as a source of clean water.

As for the distribution of aquifers is also almost evenly distributed throughout the research location, the position of the aquifer extends north-south and west-east of Kobakma city except at the location of the Kobakma market junction as seen in the picture of the aquifer cut. The depressed aquifer is located at a depth of 100 – 180 meters below the ground level with a thickness of 90 – 170 meters and can be used by the community and the local government as a source of raw water for the community.

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