



Identification of Groundwater Table Depth as A Source of Raw Water in Elelim District, Yalimo Regency

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ABSTRACT

Clean water is a fundamental need for communities, sourced from both surface water (e.g., rivers, streams, springs) and groundwater (surface and deep aquifers). Groundwater dynamics are influenced by natural factors, including geology and geomorphology, which determine aquifer characteristics such as type, depth, thickness, and permeability. Geological structures influence groundwater flow direction, while lithology affects aquifer ion concentration and water quality. Surface morphology impacts groundwater table depth and movement patterns, with morphogenesis influencing permeability, porosity, and infiltration rates. This research investigates groundwater potential in Yalimo Regency, Mountainous Papua Province. The research aims to evaluate aquifer characteristics using regional geological and geomorphological assessments complemented by advanced mapping technology. The methodology integrates field mapping with geospatial analysis to identify and delineate groundwater resources. Results provide a detailed understanding of aquifer distribution, capacity, and potential for sustainable utilization. Conclusions emphasize the importance of combining traditional and technological approaches for accurate groundwater resource assessment, offering insights for effective water management in the region.

Keywords: Groundwater, Aquifer, Geology, Geomorphology, Elelim.

INTRODUCTION

The availability of clean water is one of the global challenges that continues to increase along with the world's population growth and rapid urbanization (Yusuf et al., 2023). According to a United Nations report, more than 2.2 billion people in the world lack access to safe, clean water (Rahmawati & Firman, 2022). This is exacerbated by climate change, environmental degradation, and pressure on water resources due to human activities, such as intensive agriculture and urban development. The utilization of groundwater as a source of clean water is

crucial, especially in areas that have limited access to surface water or that face significant fluctuations in rainfall (Eryani, 2024).

Groundwater utilization has become a key solution in many parts of the world to address the need for clean water, especially in regions that face geographical and climatic constraints. According to a World Bank report, more than 30% of global clean water demand is met from groundwater, and this figure continues to increase in line with the urgent need (Pointet, 2022). However, uncontrolled exploitation of groundwater without proper management can lead to declining groundwater levels, seawater intrusion, and ecosystem damage (Hendrayana, 2010). Therefore, accurate identification of the presence and potential of aquifers is an important first step in sustainable groundwater management. This identification not only supports the provision of clean water, but also helps reduce pressure on increasingly degraded surface water resources.

Specifically, Indonesia as an archipelago with complex geological conditions faces similar challenges (Tryono, 2016). Mountainous regions in Indonesia, including in Papua, have large potential groundwater resources, but they are often not identified and optimally utilized. One such area is Elelim District in Yalimo Regency, Papua Mountains. Elelim is an area with a morphology of mountains, hills and valleys, which allows the formation of streams and potential groundwater reserves. Based on the geological map of Papua Mountains, this region has geological structures in the form of faults or rock cracks due to tectonic processes. These cracks allow water infiltration into rock cavities, forming aquifers that have the potential to become groundwater sources (Indartin & Mujib, 2020).

However, so far, the mapping and utilization of groundwater resources in Elelim District is still very limited. In this context, research that focuses on identifying the depth of the groundwater table and the distribution of aquifers is very important. The identification of groundwater potential is carried out using cutting-edge technology such as AIDU Golden Red (AGR), a geophysical instrument capable of providing a vertical picture of rock resistivity and aquifers through natural electric field measurements (Wambena et al., 2024). This technology offers high accuracy as it can map resistivity data at different depths, from shallow to deep, using high and low frequencies simultaneously (Gabàs et al., 2014).

Previous research has underscored the relevance of geophysical methods in identifying groundwater potential. For example, research by (Cahyadi et al., 2017) showed that the resistivity method can be used to identify the presence of aquifers with high accuracy in mountainous areas. (Sari, n.d.) found that natural electric field measurement technology is effective in mapping aquifer distribution in areas with complex topography. In addition, (Purwadi, 2022) mentioned the importance of groundwater mapping in areas vulnerable to clean water crisis to support sustainable water resources management. Other research by (Darwis & Sc, 2018) showed that areas with fault structures tend to have significant aquifers due to the retention space in the rock cavity.

In the context of Elelim District, the urgency of this research cannot be ignored. Groundwater is one of the potential resources that can fulfill the community's need for clean water, especially in remote areas that are difficult to access by clean water infrastructure. With proper identification, aquifer potential can be utilized sustainably for household needs, agriculture, and regional development. However, the main challenge lies in the lack of comprehensive local geophysical data, so this research also contributes to the development of a database of groundwater resources in the Papua region.

The novelty of this research lies in the use of AGR technology for the first time in the Elelim District area. This technology offers a new approach to groundwater exploration with more accurate and efficient detection capabilities than traditional methods. In addition, this study provides insight into the spatial distribution and depth of aquifers in mountainous areas that have unique geological characteristics.

Based on the above background, the purpose of this research is to determine the position of subsurface aquifers and describe the distribution of groundwater in Elelim District, Yalimo Regency. This research is expected to provide valid information on the existence and potential of aquifers that can be utilized as raw water sources in the region. The benefits of this research include three main aspects. First, from a scientific perspective, this research contributes to the development of groundwater exploration methods based on AGR technology in tropical areas with complex geological conditions. Secondly, practically, the results of this research can be a reference for local governments and related parties in planning sustainable groundwater resource management. Third, socially, this research is expected to increase the access of the Elelim District community to clean water, which in turn supports the improvement of their quality of life.

RESEARCH METHOD

This research is located in Elelim District Yalimo Regency. Geographically Elelim District is located at 138° 57' 37.98" to 139° 55' 03.99" east longitude and 3° 27' 32.40" to 4° 05' 15.20" south latitude. namely the west is bordered by central mamberamo district, the north is bordered by jayapura district, the east is bordered by yahukimo district and the south is bordered by jayawijaya district.

The method that will be carried out in this research uses the resistivity value research method with the data interpretation research method based on the results of field testing and analysis with the Papua Regional Geology map. The data taken are primary data and secondary data.

Primary data

Primary data collected are the results of Geoelectric measurement surveys using the AGR (Aidu Golden Rad) tool and taking field coordinates using GPS.

Secondary data

Secondary data is literature research data taken from several previous studies and the Papua Regional Geological map and groundwater availability map to determine the type of soil and rock at the research location.

RESULT AND DISCUSSION

Yalimo Regency

Based on the results of Geoelectric Testing Research in Yalimo Regency, Elelim District, the distribution of rocks in the Yalimo district soil layer is structured from the Lumpy Sedimentary rocks: conglomerates, breccias and sands, the Inseparable Kembelangan group: claystone, a little siltstone inserts, thin layers of lumpy limestone siltstone and sandstone, Waripi Formation: quartz sandstone, siltstone and thin siltstone rocks and Dorewo Malihan Rocks: slate, phyllite, quartz mica schist and chlorite schist.

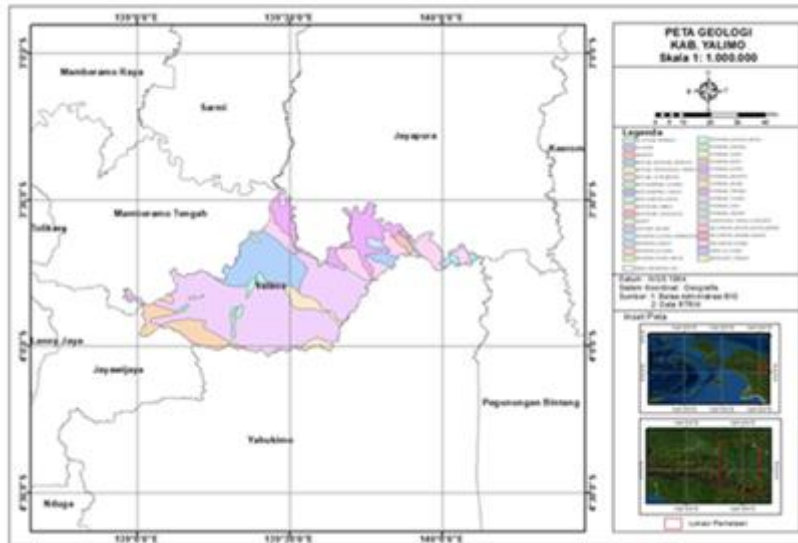


Figure 1. Geological map of Yalimo Regency

Groundwater Availability

Yalimo Regency based on the groundwater availability map (Figure 8), it can be seen that most of the western area is in the low groundwater availability category, which means that it is an area that has sufficient groundwater to less in the rainy season and very less in the dry season, the landform in this area does not support it as a water catchment area, has a depth of groundwater tends to be deep and even not measurable. While the eastern part of Yalimo Regency, included in the category of moderate groundwater availability is an area that has sufficient groundwater throughout the year, including areas with semi-permeable rock units, the landform in this area supports as a water catchment area, has a shallow to moderate depth of the groundwater table, and has a moderate to thick soil thickness as a sufficient infiltration medium. Areas with moderate groundwater potential are considered water-prone.

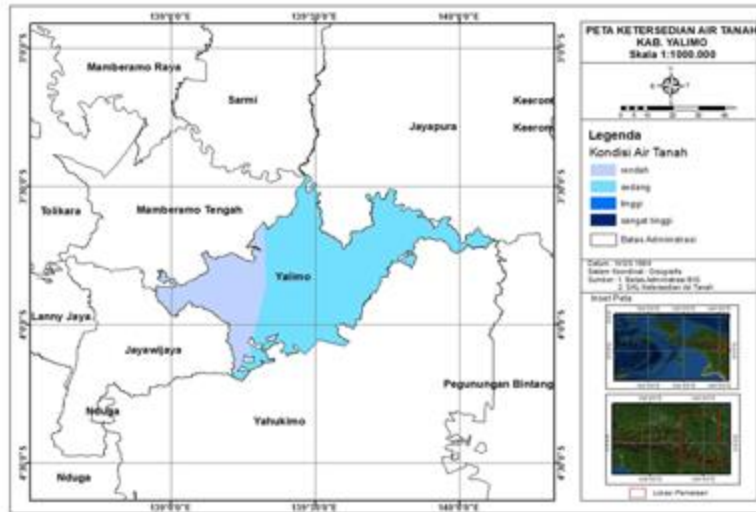


Figure 2. Groundwater Availability Map of Yalimo District

Test Results and Analysis of Goelectric Data Interpretation

Goelectric Testing Results

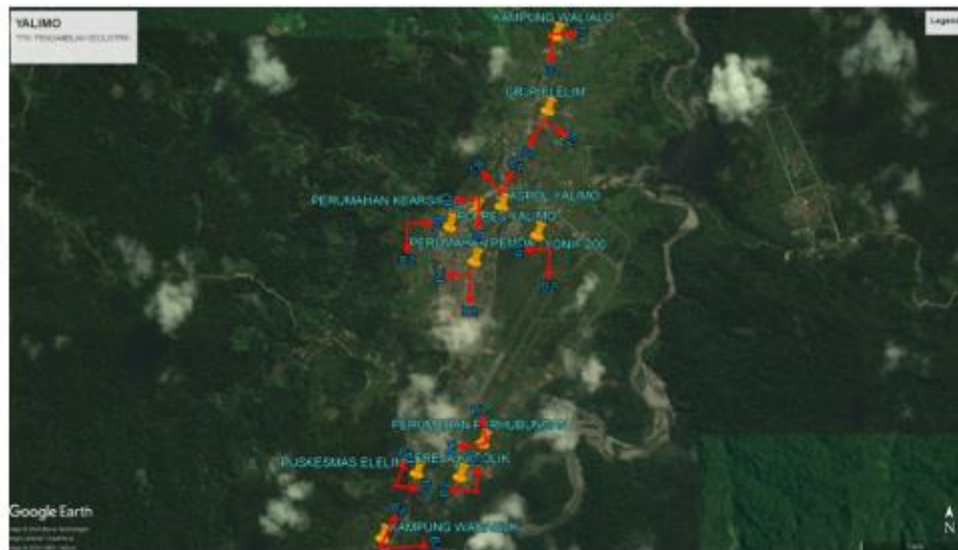


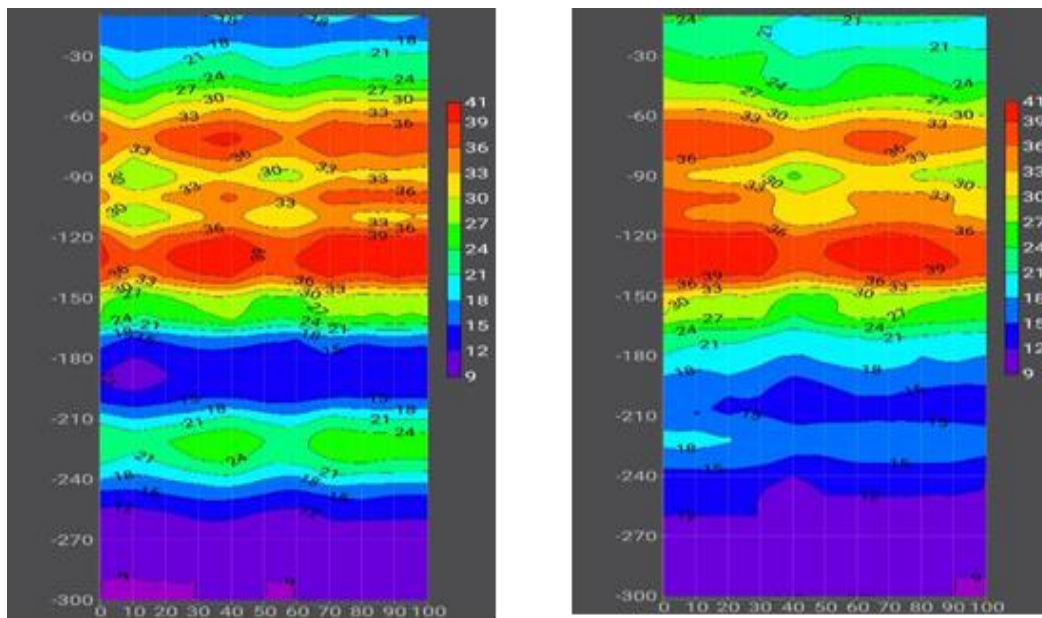
Figure 3. Layout of the Goelectric Testing Range of Yalimo District

Geoelectric data collection was carried out in the Elelim District of Yalimo Regency. In this research, Geoelectric testing was carried out at 11 test location points spread across the Elelim district of Yalimo Regency.

Table 3. geoelectric testing location points of Yalimo District

No	Location	Coordinates				
		B1		B2		Elevation
1	Yalimo Police Dormitory	3° 45' 8.702"	139° 23' 10.28"	3° 45' 44.448"	139° 23' 10.409"	

No	Location	Coordinates				Elevation
		B1		B2		
2	Archival Housing	3° 46' 15.459"	139° 23' 2.25"	3° 46' 15.46" 2.639"	139° 23' 2.639"	431 m
3	Yalimo Police	3° 46' 20.198"	139° 22' 54.528"	3° 46' 20.263"	139° 22' 54.333"	433 m
4	Yalimo Local Government Housing	3° 46' 30.37"	139° 23' 2.255"	3° 46' 30.533"	139° 23' 2.74"	440 m
5	Wagago Village	3° 47' 53.306"	139° 22' 35.978"	3° 47' 53.175"	139° 22' 35.849"	489 m
6	Elelim Health Center	3° 47' 33.921"	139° 22' 46.029"	3° 47' 33.954"	139° 22' 46.126"	460 m
7	Transportation Housing	3° 47' 24.549"	139° 23' 5.752"	3° 47' 24.712"	139° 23' 5.557"	458 m
8	GRJP Elelim	3° 45' 44.864"	139° 23' 23.631"	3° 45' 44.928"	139° 23' 23.404"	410 m
9	Walialo Village	3° 45' 22.436"	139° 23' 25.714"	3° 45' 22.436"	139° 23' 25.617"	398 m
10	Yonif 200 Elelim	3° 46' 22.266"	139° 23' 21.132"	3° 46' 22.461"	139° 23' 20.872"	428 m
11	Elelim Catholic Church	3° 47' 34.727"	139° 22' 59.056"	3° 47' 34.565"	139° 22' 59.446"	470 m



a. Span Cut B1

b. B2 Span Section

Figure 4. (a) Cross section B1 (b) Cross section B2 Yalimo Police Dormitory

Geoelectric test results at the Yalimo Police Dormitory found that in Stretch B1 the depth of the aquifer is 165 and 240 m, while in Stretch B2 it is 245 m deep.

Interpretation of Geoelectric Testing Results

In the interpretation of this research in addition to Geophysical data, Geological data is also used to assist in Geoelectric Interpretation. Because geoelectric data is also very influential on interpretation. Like the resistivity value that cannot be separated from the influence of rocks. Geoelectric data results are resistivity values. So the results of the resistivity value of geoelectric data are used to find the value of groundwater which is the target of this research with the help of geological data.

Table 4. Interpretation of Stretch B1 of Yalimo Police Dormitory

No.	Layer Sequence	Depth	Estimated Material Type	Layer Color on Diagram
1	Top Layer	0-30 m	Low to medium fracture breccia	Green
2	Layer - 01	30-60 m	Alluvial deposits of gravel, sand and clay silt interbeds	Light green
3	Layer - 02	60-110 m	Gravel mixed with sand	Orange
4	Layer - 03	110-145 m	Loamy clay	Yellow
5	Layer - 04	145-165 m	Pasiran silt	Purple
6	Layer - 05	165-210 m	Medium - high fracture breccia	Pink
7	Layer - 06	210-240 m	Pasiran silt	Yellow
8	Layer - 07	240-300 m	Medium - high fracture breccia	Pink

Table 5. Interpretation of B2 Stretch of Yalimo Police Dormitory

No.	Layer Sequence	Depth	Estimated Material Type	Layer Color on Diagram
1	Top Layer	0-55 m	Alluvial deposits of gravel, sand and clay silt interbeds	Green
2	Layer - 01	55-110 m	Gravel mixed with sand	Orange
3	Layer - 02	110-150 m	Loamy clay	Yellow
4	Layer - 03	150-180 m	Pasiran silt	Purple
5	Layer - 04	180-245 m	Low to medium fracture breccia	Pink
6	Layer - 05	245-300 m	Medium - high fracture breccia	Dark pink

Table 6. Recap of Yalimo District Interpretation Elelim District

No.	Location	Coordinate B1	B2 coordinates	Elevation	B1 Free Aquifer	B2 Free Aquifer	B1 Depressed Aquifer	Suppressed Aquifer B2
1	Yalimo Police Dormitory	3°48'5.702"	139°23'10.28"	429 m	-	-	165-210 m	245-300 m
2	Archival Housing	3°46'18.1459"	139°22'22.5"	431 m	-	-	165-210 m	170-210 m
3	Yalimo Police	3°46'0.139"	139°22'54.52"	433 m	-	-	165-210 m	170-210 m
4	Yalimo Local Government Housing	3°46'30.37"	139°22'50.535"	440 m	-	-	240-300 m	240-300 m

No .	Location	Coordinate B1	B2 coordinates	Elevation	B1 Free Aquifer	B2 Free Aquifer	B1 Depressed Aquifer	Suppressed Aquifer B2
5	Wagago Village	3°47'53.306"	139°47'53.173"	480 m	-	-	210-240 m	240-300 m
6	Elelim Health Center	3°47'43.921"	139°22'46.6029"	443 m	-	-	210-240 m	170-200 m
7	Transportation Housing	3°48'34.159"	139°22'59.044"	431 m	-	-	210-240 m	170-200 m
8	Grp Elelim	3°48'44.846"	139°22'38.601"	439 m	-	-	210-240 m	170-200 m
9	Wailalo Village	3°48'29.253"	139°25'25.614"	438 m	-	-	210-240 m	170-200 m
10	Yonif 200 Elelim	3°46'22.266"	139°21'13.132"	428 m	-	-	240-300 m	240-300 m
11	Elelim Catholic Church	3°47'34.727"	139°22'59.056"	470 m	-	-	210-240 m	145-210 m

Analysis of Resistivity Values with Interpretation shows that from 11 Geoelectric Testing locations there are no free aquifers. While from 11 locations conducted Geoelectric Testing obtained depressed aquifers with varying depths and thickness of depressed aquifers. At the location of the Yalimo Police Dormitory, Archives Housing, Yalimo Police Station, Wagago Village, GRJP Elelim and Wailalo Village, the depth of the depressed aquifer is 165-210 m from the ground level with a thickness of 30-50 m. The deepest depressed aquifer is found at the location of the Yalimo Police Dormitory. The deepest depressed aquifer is found at the location of Yalimo Local Government Housing, Elelim health center, Transportation Housing, Yonif 200 and Elelim Catholic Church with a depth of 210-300 m with a layer thickness of 30-70 m.

Placement and Depth of Groundwater Drill points

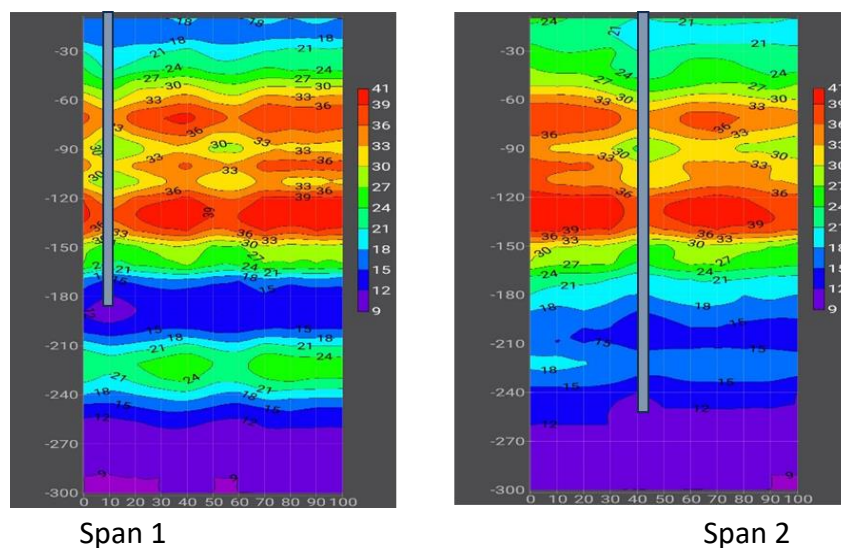


Figure 5. drill point recommendations of Stretch 1 and Stretch 2

Table 7. Recap of Yalimo District Interpretation Elelim District

No	Location	Elevation	Recommended Drill Point (Depth) B1	Recommended Drill Point (Depth) B2	Drill Point Recommendation (Distance From Starting Point)
1	Yalimo Police Dormitory	429 m	185 m	260 m	10 m, 43 m
2	Archival Housing	431 m	180 m	150 m	10 m, 34 m
3	Yalimo Police	433 m	185 m	170 m	38 m, 7 m
4	Yalimo Local Government Housing	440 m	275 m	270 m	20m, 50m
5	Wagago Village	489 m	175 m	180 m	55 m, 90 m
6	Elelim Health Center	460 m	185 m	270 m	81m, 100m
7	Transportation Housing	458 m	170 m	170 m	10 m, 60 m
8	Grjp Elelim	410 m	175 m	175 m	25 m, 0 m
9	Walialo Village	398 m	175 m	175 m	0 m, 20 m
10	Yonif 200 Elelim	428 m	270 m	270 m	50 m, 20 m
11	Elelim Catholic Church	470 m	290 m	290 m	0 m, 0 m

The geoelectric interpretation results summarized in Table 7 show variations in aquifer depth and distribution across 11 sites in Elelim District, Yalimo Regency. Aquifer depths recommended for drilling vary significantly, ranging from 150 meters at the Archive Housing site to 290 meters at Elelim Catholic Church. This variation reflects the heterogeneity of the subsurface geology in the region, which is influenced by local tectonic and lithologic characteristics. Sites such as the Yalimo Local Government Housing and Elelim Catholic Church, which have deeper aquifers, indicate the presence of denser or less permeable subsurface materials, requiring deeper drilling to reach water-bearing layers. In addition, the recommended drilling points at each site (B1 and B2) represent a certain distance from the starting point, designed to ensure optimal access to the identified aquifers.

The spatial distribution pattern shows that sites at lower elevations, such as Walialo Village (398 m), tend to have aquifers with shallower depths (175 m), while sites at higher elevations, such as Elelim Catholic Church (470 m), require deeper drilling (290 m). This pattern indicates a correlation between elevation and aquifer depth, which is influenced by gravity flow and geologic stratification of water-bearing layers.

The results of this study are consistent with previous studies. For example, (Idris et al., 2018) showed that in areas with complex topography, aquifer depths vary due to the influence of fault and fold structures that create localized zones of water accumulation. Research (Somers & McKenzie, 2020) also identified that aquifers in mountainous areas tend to be at greater depths due to the compressed nature of the geological formations, supporting the finding of deeper aquifers in locations such as Elelim Catholic Church. (Rolia & Sutjningsih, 2018) confirmed that the geoelectric method is effective in determining the optimal drilling point, with results that match between geoelectric interpretation and actual results. (Priandani, 2022) emphasized the

importance of considering the spatial distribution of aquifers in areas prone to water shortages, and recommended the use of alternative water sources such as river water or shallow wells to complement deep aquifer exploration.

Based on these results, this study not only provides an in-depth picture of the aquifer characteristics in Elelim District but also supports more sustainable water resources management in the region. The geoelectric method used has proven to be reliable and provides specific drilling recommendations according to the geological conditions of each site. This provides an important foundation for more targeted groundwater management planning, especially to address water availability challenges in mountainous areas such as Elelim.

CONCLUSION

In conclusion, the research conducted in Elelim District, Yalimo Regency aims to identify the position and characteristics of subsurface aquifers that have the potential as groundwater sources. Based on geoelectric testing at 11 locations, no free aquifer positions were identified in the study area. However, in 6 specific locations - namely the Yalimo Police dormitory, Archive Housing, Yalimo Police, Wagago Village, GRJP Elelim, and Walialo Village - a depressed aquifer with a depth of between 165 to 210 meters below the ground surface with a thickness of 30-50 meters was identified. In addition, the deepest aquifers, found at a depth of 210-300 meters with a layer thickness of 30-70 meters, are located near the Yalimo Local Government Housing, Elelim Health Center, Transportation Agency Housing, Yonif 200, and Elelim Catholic Church. These findings highlight the significant challenges posed by the absence of free aquifers and the considerable depth of the identified depressed aquifers. These results underscore the need for further hydrological studies to evaluate the volume and sustainability of aquifer water discharge. In addition, utilization of alternative water sources, such as shallow wells and surface water from rivers, is recommended to meet the water needs of the local community..

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First publication right:

Asian Journal of Engineering, Social and Health (AJESH)

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