West Science Interdisciplinary Studies
Vol. 03, No. 12, December and 2025: pp. 2442-2457

Subsurface Characterization Using Electrical Resistivity Method: A Case Study of The Bhayangkara Area, Papua, Indonesia

Erwin[1], Virman[2]
[1] Program studi Teknik Sipil, Universitas Cenderawasih and tandekerwin@gmail.com
[2] Program Studi Pendidikan Fisika and virman_uncen@yahoo.com

ABSTRACT

This study aims to identify the potential and distribution of groundwater aquifers in the Bhayangkara Complex area, Jayapura City, Papua, Indonesia, using the geoelectric resistivity method with a Schlumberger configuration. Increasing demand for clean water and limited surface water availability in Jayapura City make groundwater exploration a strategic alternative to support sustainable water supply. Geoelectric measurements were conducted at three survey lines with different orientations and electrode spacings to obtain subsurface resistivity data. Field data in the form of electric current and potential difference were processed to calculate apparent resistivity values and subsequently inverted using IPI2Win software to obtain true resistivity models. The interpretation was carried out by correlating resistivity values with lithological characteristics and regional geological conditions. The results indicate that each measurement point consists of six subsurface layers with varying resistivity values. Potential groundwater-bearing zones (aquifers) were identified at the fifth layer of all three measurement points, with resistivity values ranging from 0.5 to 300 ohm·m, depths between approximately 20.2 and 70.8 meters, and layer thicknesses from 9.94 to 37.5 meters. Among the three locations, measurement point 03 is recommended as the most suitable site for groundwater drilling due to its relatively shallow aquifer depth and adequate thickness. These findings demonstrate that the geoelectric resistivity method with Schlumberger configuration is effective for groundwater exploration and can serve as a reliable basis for groundwater development planning in urban areas with limited surface water resources.

Keywords: *Geoelectric Resistivity, Schlumberger Configuration, Groundwater Exploration, Aquifer, Jayapura City*

1. INTRODUCTION

Water, as a natural resource that is very vital for the continuity of life on earth, is indeed constant in total quantity, but its distribution is very uneven both spatially and temporally [1]. In the context of fulfilling human needs, surface water and groundwater are two main reservoirs, however, today groundwater increasingly occupies a strategic position [2]. The advantages of groundwater lie in its chemical quality which is generally better than surface water, its relatively low distribution costs because it can be utilized directly on site (in-situ), and its availability which tends to be more stable amidst climate fluctuations, making it a reliable reserve for areas with limited surface water access [3].

This situation is becoming increasingly important to examine as increasing population growth, urbanization, and residential expansion lead to a surge in demand for clean water, particularly in areas experiencing limited surface water supplies. Jayapura City is one of the areas facing high pressure on clean water availability. Rapid population growth and development are not matched by sufficient clean water production and distribution capacity. As a result, some residents must purchase water from private providers who transport it by truck, a phenomenon that reflects an ongoing water distribution crisis.

In this context, exploring and optimizing groundwater resources is a highly strategic step. However, limited data on the existence and distribution of aquifers in Jayapura City, particularly in the Bhayangkara Complex, hampers efforts to optimally utilize groundwater. Successful exploration relies heavily on a sound understanding of subsurface geological conditions.

One method that has proven effective in identifying the presence of aquifers is the geoelectric resistivity method with the Schlumberger configuration. This method is capable of investigating variations in rock resistivity below the surface to a depth of 150 meters, making it highly suitable for aquifer mapping. Several studies have demonstrated the success of this method in mapping aquifers in various regions, such as Palopo [4], Parangluhu Beach, Bulukumba [5].

2. LITERATURE REVIEW

2.1 Groundwater

Groundwater is a natural resource that supports life and development activities. Therefore, groundwater exploration and exploitation are necessary. Water originates from surface water, a product of the hydrological cycle where rainwater seeps into the ground. Furthermore, there is juvenile water, groundwater formed from magmatic processes, and groundwater trapped in sedimentary rocks, known as fossil water. Groundwater, based on geographic and morphological conditions, can be found in volcanic deposits, alluvial deposits, sedimentary rocks, crystalline rocks, and glacial deposits. The presence of groundwater in hard (compact) rocks is controlled by geological structures, namely rock deformation in the form of faults, folds, fractures, and fractures. Fault lines have dimensions of length and width that vary from minor to tens of kilometers.

Groundwater is formed through hydrological processes, stored and moving in layers called aquifers [6]. Aquifers are subsurface rock layers that can store and release significant amounts of water, such as gravel, sand, limestone, and volcanic rock [7]. Thus, aquifers are essentially pockets of water found underground. Important aquifer lithologies in Indonesia include:

1. Alluvial deposits: These are deposits resulting from the breakdown of pre-existing rocks. Groundwater in these deposits fills the spaces between the grains, and these deposits are distributed across flat areas.
2. Young volcanic deposits: These deposits are the result of volcanic activity, consisting of both loose and compacted rock. Groundwater in these deposits occupies both the intergranular spaces in the loose material and the fractures or cavities in the solid rock. These deposits are distributed throughout volcanic regions.
3. Limestone: a marine sediment containing carbonate that has been brought to the surface by geological processes. Groundwater here fills confined cavities and channels created by dissolution. These deposits form a distinctive morphology called karst.

There are two types of underground groundwater based on the amount of pressure experienced, namely confined aquifer and unconfined aquifer. Unconfined aquifer is stored near the surface to a depth of 40 meters, saturated with water. The boundary layer is an aquitard, only at the bottom and there is no aquitard boundary in the upper layer, the boundary in the upper layer is the groundwater table. Confined groundwater is stored at a depth of more than 40 meters. Confined aquifers are located below the impermeable layer and have a pressure greater than the atmosphere. The difference in pressure that occurs in the two types of groundwater is due to the presence of an impermeable layer, namely a layer that does not contain water, which can be a layer of clay (claystone) [8].

Groundwater levels are generally not horizontal, but tend to follow the topography above them. If there is no rain for a long period, the water level below the hill will slowly decrease until it is level with the valley. Figure 2.2 shows that aquifer layers tend to follow the topography. The groundwater flow model begins in the recharge zone. This area is where surface water undergoes a process ofinfiltration by gravity through holes/pores or rock fractures, [9].

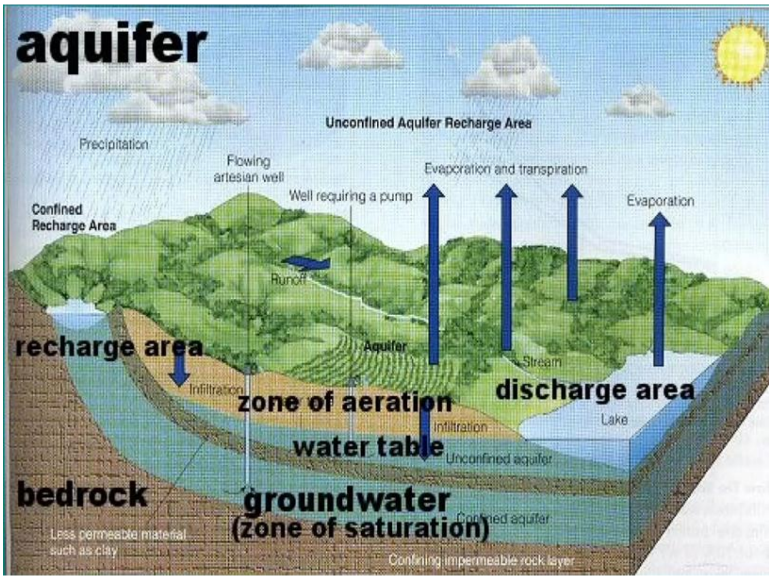

Figure 1. Recharge and discharge area [9]

The potential and presence of groundwater below the surface are controlled by, among other things, vegetation, rainfall, slope gradient, surface rock type, and the porosity of the subsurface layers. Greater porosity is not always accompanied by better permeability. For example, clay has large porosity but very low permeability. Alluvium layers in the same rock type (for example, both clay) have smaller porosity than dilluvium and Neo-tertiary layers. The amount of rock porosity is influenced by the physical properties of the rock, including density, cementation, grain shape and size, and grain sorting, while rock permeability is the speed of water flow in the soil [10].

Groundwater cannot be seen directly on the surface, so there are many ways to determine or predict groundwater availability. Indirect groundwater investigations are known as geophysical estimation. The most widely used geophysical estimation to predict groundwater availability is geoelectric resistivity. Geoelectrical measurements involve measurements above the Earth's surface, from which the properties (lithology) of the subsurface can be interpreted [11].

2.2 *Existence of Groundwater*

When discussing groundwater, one of the factors considered crucial is geological formation, making it crucial to study its characteristics. Geological formations are rock formations that store large amounts of groundwater. These geological formations are known as aquifers. These layers consist of loose materials such as sand and gravel, or hardened materials such as sandstone and limestone.

Water in the pores of an aquifer is affected by the force of gravity, so it tends to flow downward through the pores of the material. Resistance to underground flow varies greatly, and the permeability of the material is a measure of that resistance. Conductors (aquifers) with large pores, such as gravel, are said to have high permeability, while layers with very small pores, such as clay, whose pores can only be seen under a microscope, have low permeability.

Aquifers are divided into two, namely unconfined aquifers and confined aquifers, as shown in Figure 2.

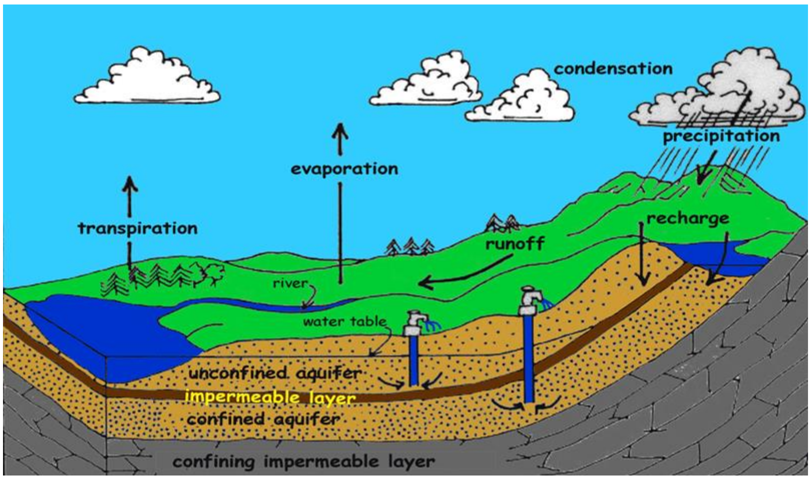

Figure 2. Unconfined aquifer and confined aquifer [9]

Unconfined aquifers form when the water table forms the upper boundary of the saturated soil zone. Groundwater levels fluctuate depending on the amount and speed of water (rain) infiltration, groundwater extraction, and soil permeability. Confined aquifers, also known as artesian aquifers, form when deep groundwater is confined by an impermeable layer, creating a pressure below that layer that is greater than atmospheric pressure.

2.3 *Groundwater Composition*

Groundwater is a good solvent. Its contact with a solid matrix, in this case soil with various minerals, allows groundwater to contain various dissolved components or elements from the soil material, in the form of dissolved cations, dissolved anions, and non-ionic solutions.

Anions such as SiO2, chloride, and carbonate are the most common examples of compounds derived from the natural dissolution of minerals. Important gases found in groundwater include oxygen, carbon dioxide, hydrogen sulfide, and methane. In addition to inorganic substances, organic compounds are also found dissolved in groundwater, with concentrations reaching 2000 mg/L in some locations (Hull et al., 1984). In shallow groundwater, the most common organic compounds are humic acid and sulfuric acid. In deep groundwater, the most frequently found organic compounds are acetic acid and propionic acid (Table 1).

For cations dissolved in groundwater (uncontaminated) are dominated by Ca2+, Mg2+, Na+ and K. Meanwhile, the anions that are commonly found are HCO3-3, CO-3, SO4-4, and Cl-. The concentration of anions and cations will be equivalent or almost the same if the soil pH is neutral (Notodarmojo, 2005).

2.4 Hydrogen Potential (pH) of Soil

Soil colloidal particles, consisting of clay minerals, metal oxides, hydroxides, and organic compounds, generally have an electrostatic charge. The pH value can influence the electrostatic charge of a colloidal particle, shifting from positive to negative or vice versa, reducing its potential. The pH value can also determine whether precipitation or dissolution will occur.

Clay has the ability to absorb or release H+ ions, which can then become free ions after dissociating in groundwater. The degree of dissociation and ionization in the soil solution determines the soil's acidity. One characteristic of clay is that it undergoes spontaneous decomposition when saturated with hydrogen, where the hydrogen ions then penetrate the octahedral layer and replace Al atoms through a substitution reaction.

The released aluminum will be absorbed by other, more complex clays, rapidly forming an Al-clay complex. Al3+ ions can hydrolyze, producing H+ ions. This reaction will increase the H+ concentration in the soil.

Indonesia's pH is generally slightly acidic, ranging from 4 to 7. Peat soils in swampy areas, such as those found in Kalimantan and Sumatra, can have lower pH values. Soil pH in limestone mountains is generally relatively higher than in volcanic areas. The relatively low pH in tropical regions is generally due to high rainfall and a high organic content.

Clay and humus in the soil have important properties because they have the ability to act as buffers to reduce pH fluctuations caused by the addition of acids or bases. Clay or clay minerals are produced from the weathering process of rocks, the weathering process is one of the important processes that contributes to the presence of ions in soil solutions or groundwater through the dissolution process. Several types of gases found in groundwater such as CO2, SO2 and NH3, when dissolved in water will undergo an acid-base reaction and change into CO2 (aq), H2CO3, SO2, H2O(aq), and NH3(aq).

2.5 Geoelectric Resistivity

Geoelectric resistivity is a geophysical method widely used for groundwater exploration, geothermal energy exploration, environmental studies, and other studies. This method examines rock layers based on differences in their conductivity. The basic principle of this geophysical method is the presence of anomalies, namely differences in the physical properties of the object being searched for and the soil covering it. The physical properties used in the geoelectric resistivity method are electrical properties. Geophysical methods that utilize electrical properties include resistivity, self-potential, and induced polarization [12].

Geophysical research to determine conditions beneath the Earth's surface involves measuring the physical parameters of rocks within the Earth's surface. These measurements can be used to interpret the properties and conditions beneath the Earth's surface, both vertically and laterally [12].

The use of geoelectricity is not only dominant in exploration activities but has also expanded to environmental issues. Geoelectric resistivity is one of the geophysical methods that can be applied effectively in monitoring environmental problems quickly and on a large scale. Besides geoelectric resistivity, there are several geophysical methods that can be used for environmental problems, including self-potential, remote sensing, and high-resolution aerial photography. However, the use or application of these methods must be based on considerations, namely that the method chosen must be appropriate to the possible response of the physical properties to its surroundings [13].

a. Basic Geoelectric Theory of Resistivity

Geophysical research to determine conditions beneath the Earth's surface involves measuring the physical parameters of rocks within the Earth's surface. These measurements can be used to interpret the properties and conditions beneath the Earth's surface, both vertically and laterally [12].

This method uses the assumption that the earth is homogeneously isotropic. With this assumption, the measured resistivity is actually independent of the electrode spacing. In reality, the earth consists of layers with different ϱ. So the measured potential is the influence of these layers. Therefore, the measured resistivity value is not the resistivity value for one layer only, this is especially true for wide electrode spacing. The measured resistivity value is called the apparent resistivity value. The apparent resistivity is formulated as [12]:

$$\rho_a = K \frac{\Delta V}{I}, \quad R = \frac{\Delta V}{I} \quad \ldots\ldots (1)$$

Where ϱa is the apparent resistivity, K is the geometric factor, ΔV is the potential difference between the two potential electrodes and I is the injected current.

Based on equation (1), it can be seen that the apparent resistivity value depends on the geometry of the electrode configuration used. The geoelectric resistivity method has several configurations that can be used, including the Schlumberger configuration, Wenner configuration, dipole-dipole configuration, etc. In this study, the Schlumberger configuration was used (Figure 1).

For Schlumberger electrode rule, the current electrode spacing is much wider than the potential electrode spacing as in Figure 3.

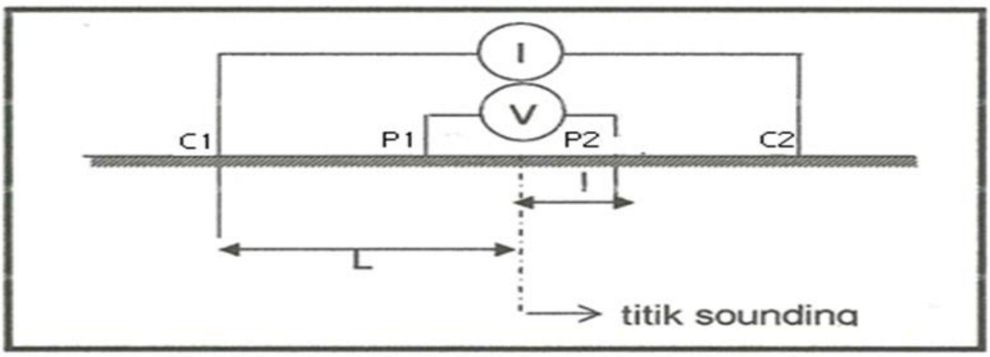

Figure 3. Schlumberger configuration [12]

From equation (1), if it is derived, the apparent resistivity for the Schlumberger configuration is obtained as follows:

$$\boldsymbol{\rho = 2\pi \left[\left(\frac{1}{r_1} - \frac{1}{r_3}\right) - \left(\frac{1}{r_2} - \frac{1}{r_4}\right)\right]^{-1} \frac{\Delta V}{I}}$$

Where: r_1= distance from point P1 to the positive current source (L - l)
r_2= distance from point P1 to the negative current source (L + l)
r3 = distance from point P2 to the positive current source (L + l)
r4 = distance from point P2 to the negative current source (L - l)

This results in the geometry factor (K) and apparent resistivity for the Schlumberger electrode being [12].:

$$\boldsymbol{\rho_s = K_s \frac{\Delta V}{I}}$$, with Ks .... (2)= $\frac{\pi (L^2 - l^2)}{2l}$

Generally, the Sclumberger method is carried out with the distance between the current electrodes (C1 C2) made 10 times or more the distance between the potential electrodes (P1 P2).

Each configuration has a different depth penetration, so that in measuring depth penetration is one of the factors that is taken into consideration in selecting the electrode configuration, other factors are the type of structure, sensitivity of the tool, and the level of noise present.

b. Factors Affecting Resistivity Values

The subsurface structure is likely composed of layers with varying resistivities. Many factors influence this resistivity value, including:

a. Water content, the medium containing water has a smaller resistivity
b. Porosity is the ratio of the volume of cavities (pores) to the volume of the rock itself. Porosity is expressed as a percentage of volume. A larger pore volume in a rock will contain more fluid, resulting in a lower resistivity value. In this regard, there is an empirical formula known as Archie's Law, as follows:

$$\boldsymbol{\rho = a\rho_w \ \emptyset^n S^m}$$

Where = resistivity of the rock containing fluid (ohm m), a and m are constants (0.5 < a < 2.5 , 1.3 < m < 2.5), = resistivity of water (ohm m) , = porosity, n = 2 and S is the portion of the rock pores containing fluid.ρ ρ_w $\emptyset$

Temperature, the resistivity of a rock is inversely proportional to its temperature, the relationship between temperature and resistivity is shown by the following equation:

$$\boldsymbol{\rho_w = k\, e^{-0,00821\, t}}$$

Where is the fluid resistivity (ohm m), k = constant, depending on the electrolyte concentration in the fluid and t = temperature. Based on this equation, it can be seen that if the temperature increases, the resistivity will decrease exponentially. ρ_w

3. Development of Geoelectric Resistivity

The geoelectric method is a geophysical method for estimating geological conditions beneath the surface, particularly the type and properties of rocks based on their electrical properties. Data on rock electrical properties, or resistivity, is grouped and interpreted taking into account local geological conditions. Rock electrical properties can vary due to differences in their mineral composition, porosity, and fluid content, among other factors.

Geoelectrical measurement results cannot be used to definitively determine rock type, given the many factors that influence rock resistivity. However, geoelectrical methods can be used to estimate the presence of water-bearing rock formations (aquifers) in groundwater exploration, and the presence of rock formations associated with mineralized zones in mineral exploration. In engineering and environmental studies, geoelectrical methods also play a role in estimating dam leaks, pollutant fluid dispersion, and so on.

3. METHODS

3.1 Geoelectric Measurement Activity Location

This geoelectric data collection was carried out in the Bhayangkara complex area of Jayapura City at coordinates 2°36'–2°37' South Latitude and 140°40'–140°41' East Longitude. Data collection began with a preliminary survey, based on the preliminary survey, there were 3 (three) tracks. This preliminary survey was also used to collect relevant scientific references—including journal articles, proceedings, and technical documents—which were then used as a conceptual and methodological basis for the research. In addition, all equipment used in data collection had been calibrated beforehand. Calibration was carried out to ensure the accuracy and validity of data obtained in the field. The main instrument used was the Naniura 328 NRD Resistivitymeter, equipped with two current electrodes and two potential electrodes connected by copper cables, a 100-meter Roll Meter ensured the accuracy of the distance between the electrodes. The initial, middle, and final coordinates of the track were recorded using a Garmin 60 CSx GPS with an accuracy of ±3 meters. Smooth communication between teams in the field using mobile phones, and supporting equipment used in the form of hammers, umbrellas, and stationery supports electrode planting, weather protection, and data recording.

Geoelectric resistivity measurements were conducted at 3 (three) locations, each with a different stretch direction and length. The first measurement point (01) was conducted in a north-south direction and had a stretch length of AB/2 = 250 meters. Meanwhile, the second measurement point (02) was conducted in an east-west direction with a stretch length of AB/2 = 175 meters and the third measurement point was in an east-west direction with a track length of 100 meters.

3.2 Research Design

The research location is in an area with relatively uneven topography, but around the location there are a number of buildings that act as limiting factors, so that the maximum measurement span is difficult to achieve.

The measurement method used is to measure the potential difference (volts) and electric current (mA) resulting from each change in the position of the current electrode (AB) and potential electrode (MN). In this case, the Schlumberger electrode configuration is used, which is a common configuration in geoelectric surveys because it can be used for both mapping (lateral mapping) and sounding (vertical cross-section) purposes. In this sounding resistivity method, the electrode spacing is changed gradually to obtain data on the variation in resistivity with depth.

In accordance with the Schlumberger configuration principle, the spacing between current electrodes (AB) is set to be larger than the spacing between potential electrodes (MN). This is done to ensure a greater depth of current penetration into the ground surface, which is very important in groundwater studies.

3.3 Work procedures

3.3.1 Measurement Preparation

The initial step in this research was a preliminary survey of the research site. The purpose of this survey was to determine the most representative measurement points and to assess the surrounding environmental conditions that could affect the measurement process, such as the presence of buildings, land contours, and terrain accessibility.

After the measurement point locations are determined, the equipment used for data acquisition is prepared. All primary and supporting equipment is prepared and tested to ensure operational feasibility in the field.

The measurement path is determined based on the desired geoelectric interpretation design—whether it is predominantly lateral (mapping) or vertical (sounding)—and by taking into account topographic conditions and physical obstacles at the location, such as buildings and vegetation.

3.3.2 Measurement Implementation

Measurements were made using the Schlumberger configuration resistivity method. In this method, current electrodes (AB) are installed with gradually increasing spacing (sounding), while potential electrodes (MN) are kept centrally spaced with a smaller spacing than AB. This allows resistivity data to be obtained in stages based on the depth of electric current penetration.

The measurement and electrode placement techniques were carried out according to standard procedures as depicted in Figure 3 (see appendix). The field data obtained consisted of current strength, potential difference, and apparent resistivity calculations (Appendix 3), which will then be processed for subsurface analysis and interpretation.

3.3.3 Measurement Stages

The implementation of geoelectric measurements in this study began with a number of systematic steps to ensure the quality of data obtained in the field. The initial stage began with tool calibration, which ensured that all equipment was ready for use. Checks were carried out on the completeness and suitability of the cables (unbroken), as well as the power of the battery or accumulator used, which must meet the minimum voltage requirement of 12 volts. After calibration, field activities continued with the following steps: Stretching the meter, plugging in the four electrodes, connecting to the geoelectric tool using cables, then recording data by injecting current.

During the data acquisition process, the parameters measured include electric current (in milliamperes) and potential difference (in volts). Electric current is passed through two current electrodes (AB), while the potential difference response is recorded through the potential electrode (MN). The resulting potential difference value is the result of current propagation in the subsurface medium, which has a certain resistance value (expressed in ohms). This data serves as the primary basis for analyzing subsurface conditions.

3.3.4 Data processing

The collected field data, in the form of potential difference (volts) and current (mA), are then processed to obtain the apparent resistivity value (ρa). The calculation is carried out using the standard resistivity equation, where the apparent resistivity value is obtained from the product of the geometric factor and the quotient of the potential difference and the flowing electric current.

All apparent resistivity values were then input into the IPI2Win software for inversion. This process aims to transform the apparent data into a resistivity representation that more closely approximates the actual conditions (true resistivity). The modeling results are displayed as a two-dimensional cross-section, representing the distribution of subsurface lithology, the depth of each layer, and its thickness (Appendix 4).

Interpretation of lithology types based on resistivity results is carried out by considering several geophysical principles. Loose sedimentary rocks generally exhibit lower resistivity values than more compact rocks. Similarly, rocks containing water have lower resistivity values than dry ones. The salt content of the water also has a significant influence—the higher the salinity of the groundwater, the lower the recorded resistivity value.

With this approach, the resistivity data processing model is expected to be able to describe subsurface conditions more accurately, especially in identifying zones that have the potential to contain groundwater.

4. RESULTS AND DISCUSSION

4.1 Measurement results

Primary data obtained from geoelectric measurements consists of potential difference (volts) and current (amperes). This data is used to calculate apparent resistivity (ϱa), an early indicator of subsurface electrical properties. These apparent values are then inverted using IPI2Win software (Appendix 4), which generates true resistivity. The results obtained from the three trajectories are shown in the table below.

Table 1. Results of Geoelectric Data Processing

No	Location	Layer	Resistivity (ohm m)	Thickness (meter)	Depth (meter)
1	01	1	7.36	1.04	1.04
		2	858	3.97	5.01
		3	2610	13.5	18.5
		4	414	35.6	54.1
		5	100	16.7	70.8
		6	1122	∞	∞
2	02	1	489	0.38	0.38
		2	7.74	0.15	0.53
		3	133	2.12	2.64
		4	17.1	15.4	18
		5	43	37.5	55.5
		6	1995	∞	∞
3	03	1	359	0.65	0.65
		2	346	1.62	2.27
		3	224	0.895	3.16
		4	112	7.11	10.3
		5	96.2	9.94	20.2
		6	4084	∞	∞

This geoelectric data collection was conducted in the Bhayangkara complex area of Jayapura City at coordinates 2°36'–2°37' South Latitude and 140°40'–140°41' East Longitude. The actual resistivity reflects more realistic subsurface conditions. The inversion model depicts the number of layers, their thickness, and the range of resistivity values closely related to the rock type and water content within them.

Interpretation of rock types is carried out by comparing the obtained resistivity values with regional geological data and standard literature, specifically referring to the rock resistivity concept developed by Telford [12]. The data processing model presented in Appendix 4 shows the vertical (depth) variation in resistivity. Based on the magnitude of the resistivity values in each layer, and taking into account local geological conditions, the rock type at each point can be estimated. Furthermore, the results of the analysis of the subsurface model from each measurement point can be concluded as follows:

4.2 Interpretation Discussion

4.2.1 Interpretation of Geoelectric Measurement Results at Point 01

Geoelectric measurements at point 01 were conducted using a 250-meter AB/2 section. Based on the table above, a subsurface model consisting of six main layers was obtained. Each layer has a different resistivity value, which is then interpreted as a specific rock type based on local characteristics and geophysical principles.

The first layer showed a resistivity value of 7.36 ohm meters with a thickness of 1.04 meters. This low resistivity value indicates the presence of relatively dense sandy clay material. This is supported by the soil's relatively high water content due to rainfall.

The second layer has a resistivity value of 858 ohm meters, is 3.97 meters thick, and reaches a depth of 5.01 meters. This value indicates a more compact sandy clay composition (a function of depth), making it drier than the first layer. This predominantly clay layer prevents rainwater from seeping deeper.

The third layer recorded a high resistivity value of 2,610 ohm meters, with a thickness of 13.5 meters and a depth of approximately 18.5 meters. This layer is considered highly resistive, which generally indicates the presence of impermeable clay or bedrock.

The fourth layer shows a relatively low resistivity value compared to layer three, at 414 ohm m, and is suspected to be a mixture of sand and clay. This sand-dominated layer is already an aquifer, but due to minimal rainfall, the water is thought to have seeped into the lower layers.

This value indicates a high probability that the layer consists of clayey sand with improved porosity and permeability. With these characteristics, this layer has the potential to become an aquifer zone, a groundwater-bearing layer that is productive enough to be utilized.

The fifth layer, located below a depth of 70.8 meters, has a very low resistivity value of 100 ohm meters. This value indicates that the layer is likely composed of clayey sand with a high level of porosity and permeability. With such characteristics, this layer has the potential to be an aquifer zone, a groundwater-bearing layer that is productive enough to be utilized. The sixth layer, with a resistivity of 1122 ohm meters, indicates that this layer is impermeable, unable to store or allow groundwater to pass through.

4.2.2 Interpretation of Geoelectric Measurement Results at Point No. 02

Geoelectric measurements at point No. 02 were carried out with a 176-meter AB/2 stretch and an East-West trajectory. Based on the table above, trajectory 02 consists of 6 (six) layers. The rock types for each layer are as follows:

The first layer has a resistivity value of 489 ohm·m and a thickness of 0.38 meters. This layer is sandy clay. This high resistivity value is due to the porosity of the sand material, which is not saturated with water (seeping) or dry, resulting in suboptimal current distribution.

The second layer showed a decrease in resistivity to 7.74 ohm·m, with a thickness of 0.15 meters and a depth of 0.53 meters. This layer indicates a more compact, fluid-filled porosity due to recent rainwater seepage.

The third layer, with a resistivity of 133 ohm·m and a thickness of 2.12 meters, is located at a depth of 2.64 meters. This relatively high resistivity indicates that this layer is more resistive due to the lack of fluid in it.

The fourth layer exhibits a relatively low resistivity of 17.1 ohm·m, with a thickness of 15.4 meters and a depth of up to 18 meters. Based on these characteristics, the layer is thought to be clayey sand, which has high potential as a productive aquifer zone. The groundwater content in this layer is likely quite saturated with groundwater chemically rich in metals.

The fifth layer, with a thickness of 37.5 meters, at a depth of 55.5 meters, shows a very low resistivity value of only 43 ohm·m. This layer is dominated by clayey sand material that has the ability to store and drain groundwater, making it a potential aquifer for groundwater. Compared to the groundwater in the layer above it, the metal content is relatively low. The sixth layer, with a resistivity value of 1995 ohm·m, functions as an impermeable layer, where this layer cannot be passed by groundwater.

4.2.3Interpretation of Geoelectric Measurement Results at Point No. 03

Geoelectric measurements at point No. 03 were carried out with a 100-meter AB/2 stretch and an East-West trajectory. Based on the table above, trajectory 03 consists of 6 (six) layers. The rock types for each layer are as follows:

The first layer has a resistivity value of 359 ohm·m with a thickness of 0.65 meters. This layer is sandy clay. This high resistivity value is due to the porosity of the sand material which is not saturated with water (seeping) or not compacted so that the porosity is filled with air, resulting in less than optimal current distribution.

The second layer showed a resistivity value nearly identical to the first layer, at 346 ohm·m, with a thickness of 1.62 meters and a depth of 2.27 meters. This layer indicated the porosity of the material, consisting of loosely compacted clay sand and air, which hindered the flow of current.

The third layer, with a resistivity of 224 ohm·m and a thickness of 0.895 meters, is located at a depth of 3.16 meters. Its relatively lower resistivity than the previous layer indicates fluid seepage and a denser layer due to pressure from the layer above.

The fourth layer exhibits a relatively low resistivity of 112 ohm·m, with a thickness of 7.11 meters and a depth of up to 10.3 meters. Based on the characteristics of this layer, it is estimated to be clayey sand, which has the potential to act as an aquifer zone.

The fifth layer, with a thickness of 9.94 meters, at a depth of 20.2 meters, shows a very low resistivity value of only 96.2 ohm m. This layer is dominated by clayey sand material that has the ability to store and transmit groundwater, making it a potential aquifer for groundwater. The groundwater content in this layer is likely quite saturated with groundwater. The sixth layer, with a resistivity value of 4084 ohm m, functions as an impermeable layer, meaning it cannot store or transmit groundwater.

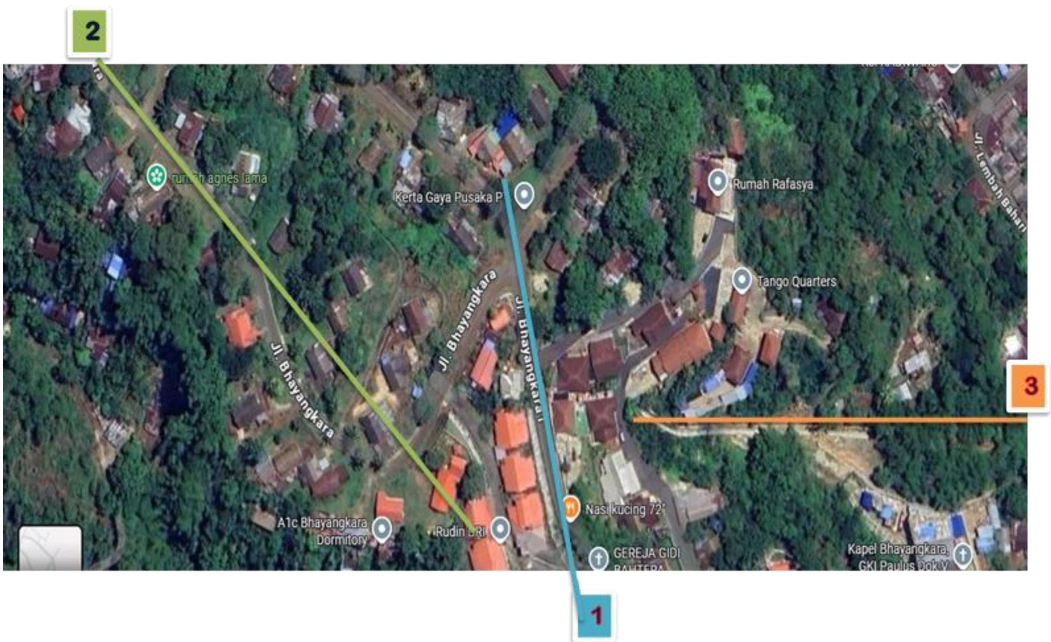

Figure 4. Geoelectric Survey Location Points in the Bhayangkara area of Jayapura City

Point 1: 165 meters above sea level (MSL)
Point 2: 205 meters above sea level (MSL)
Point 3: 121 meters above sea level (MSL)

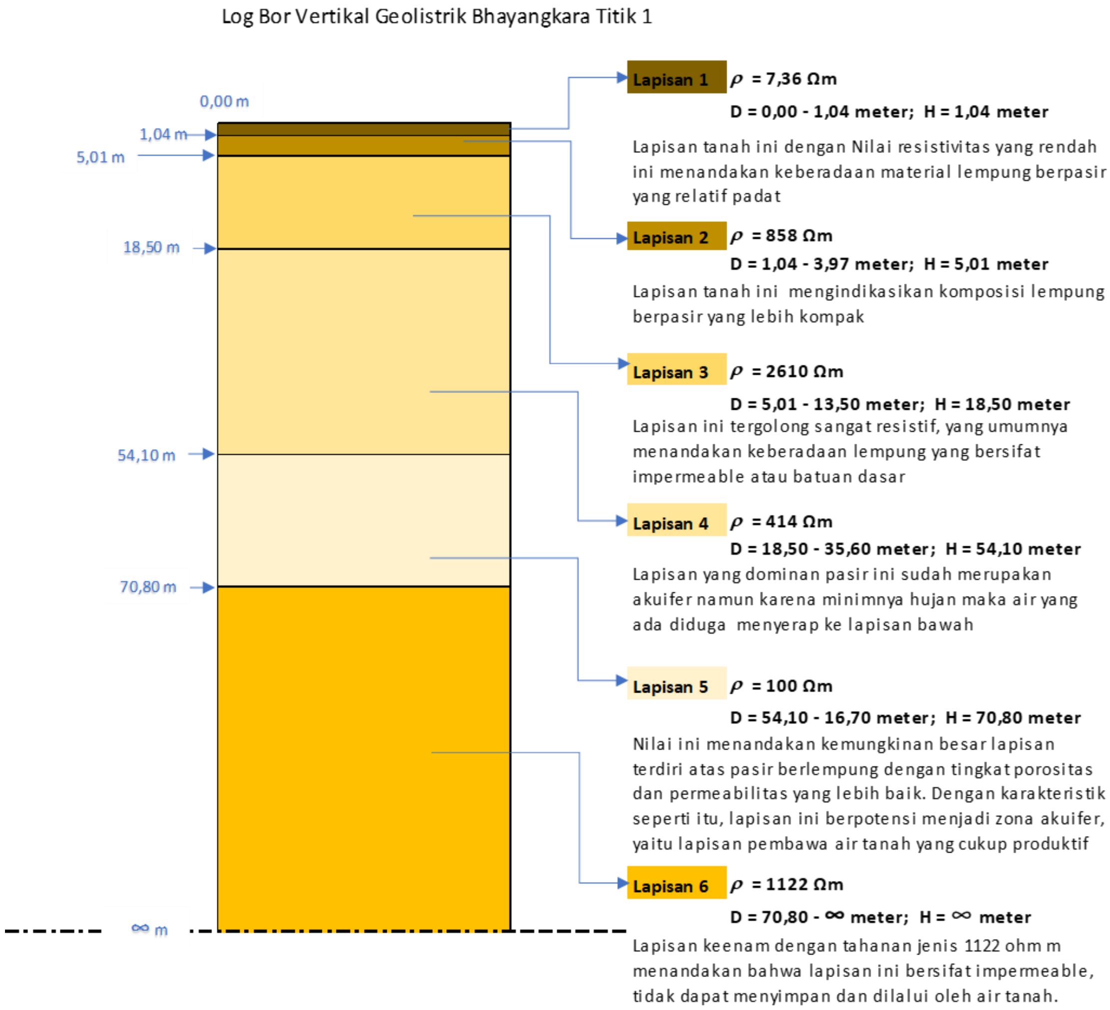

Figure 5. Bhayangkara Geoelectric Vertical Drill Log Point 1

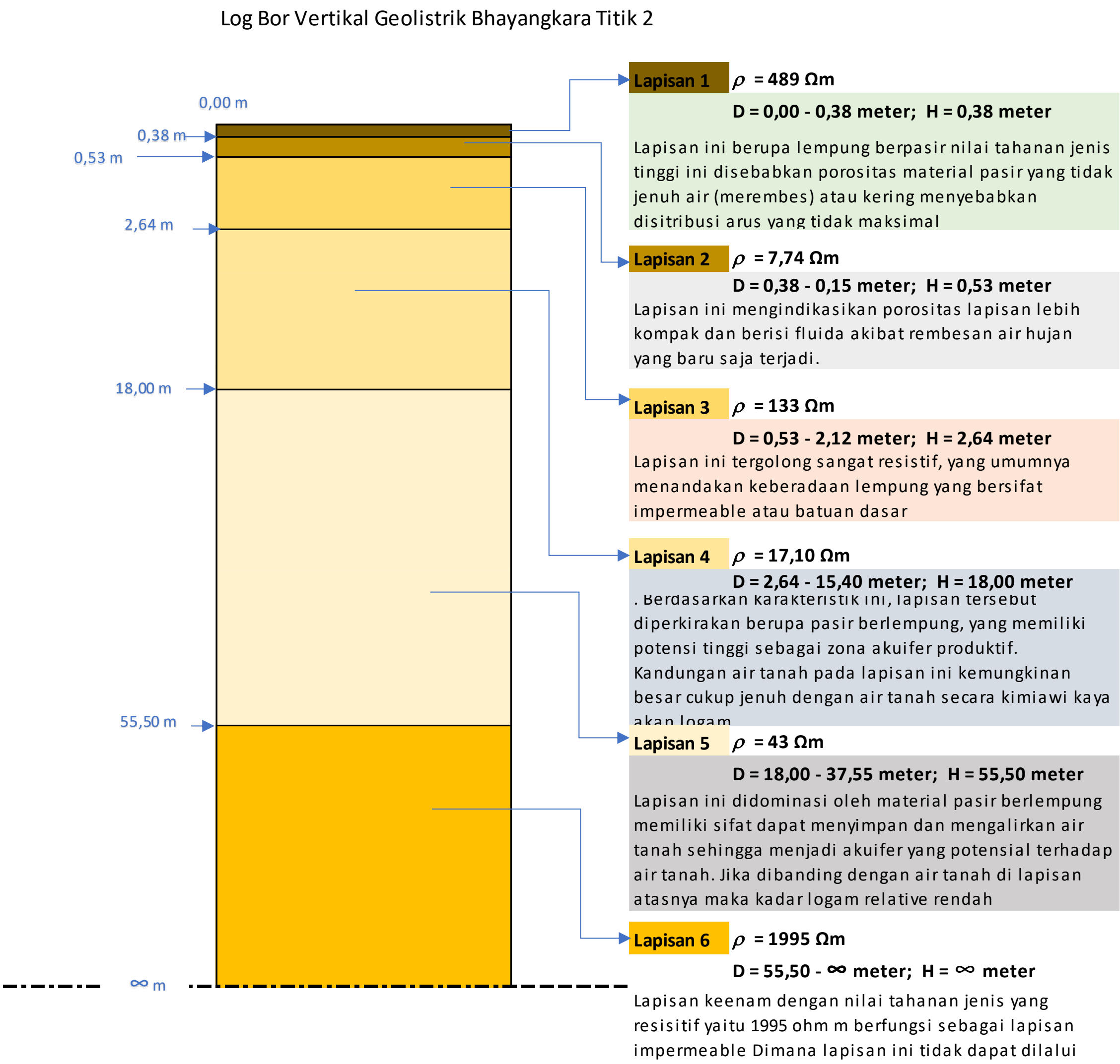

Figure 6. Bhayangkara Geoelectric Vertical Drill Log Point 2

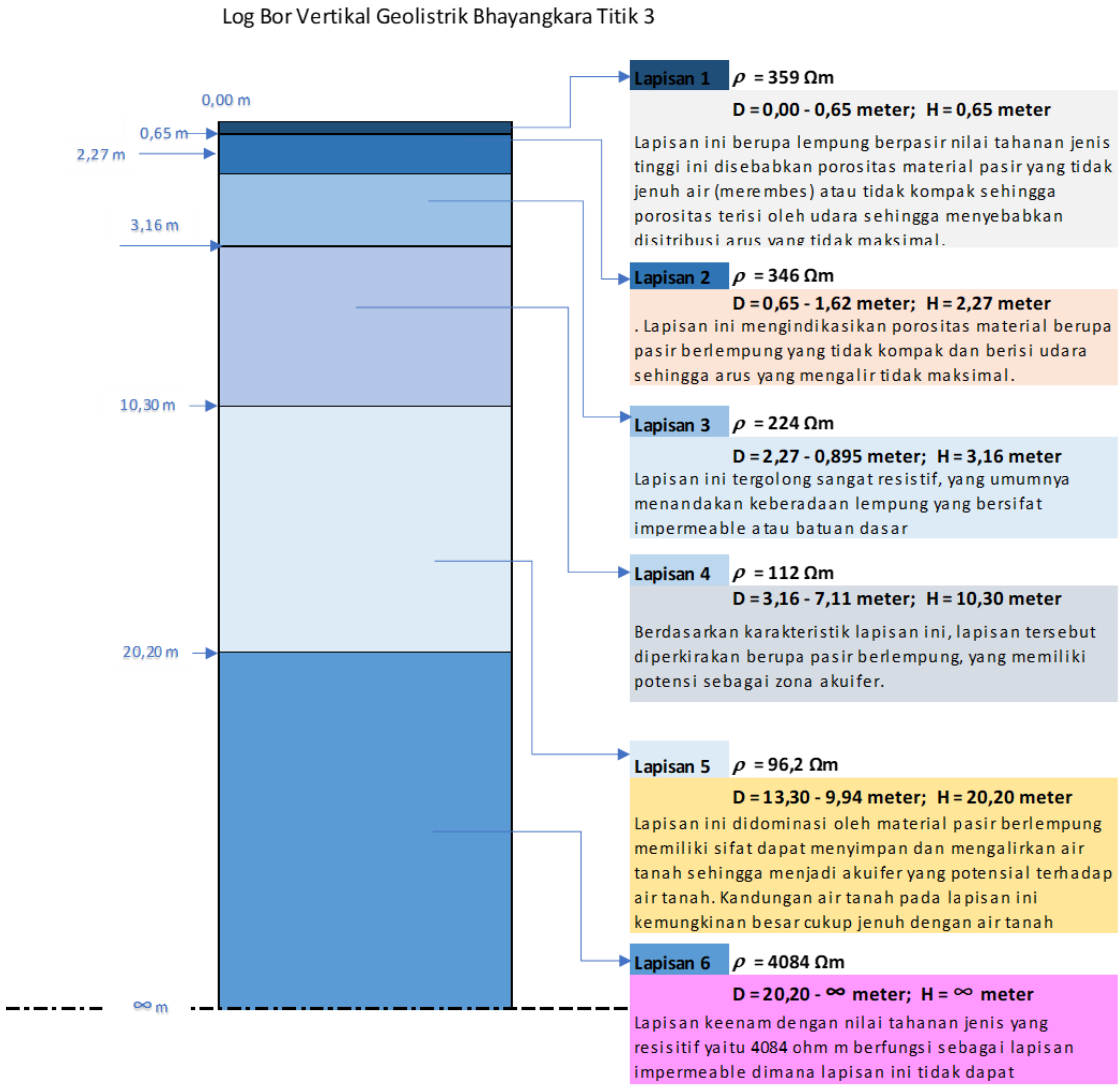

Figure 7. Bhayangkara Geoelectric Vertical Drill Log Point 3

CONCLUSION

This geoelectric data collection was carried out in the Bhayangkara complex area of Jayapura City at the coordinate range of 2°36'–2°37' S and 140°40'–140°41' E. Based on the results of the interpretation of geoelectric data, potential groundwater (good aquifer) was found at the three measurement points. At measurement point 01 coordinates S 020 31.798' E 140 42. 725 is located in layer 5 (five). The layer thickness is 16.7 meters at a depth of 70.8 meters. For measurement point 02 coordinates S 020 31. 775' E1400 42. 794 is located in layer 5 (five), the layer thickness is 37.5 meters at a depth of 55.5 meters. Meanwhile, for measuring point 03 coordinates S 020 530.13 E 1400.71.380 is located in layer 5 (five) with a layer thickness of 9.94 meters at a depth of up to 20.2 meters. These three measuring points have resistivity values that fall within the criteria of layers associated with groundwater, namely showing the resistivity value of the material table associated with groundwater, namely 0.5 - 300 ohm m. Based on this information, it is recommended that groundwater drilling activities be carried out at measuring point 03 at a depth of 20 meters.

REFERENCES

[1] Zeffitni (2013). "Agihan Spasial Potensi Airtanah Berdasarkan Kriteria Kualitas di Cekungan Airtanah Palu Provinsi Sulawesi Tengah." Jurnal Geografi 11 (22): 97-106.

[2] Sulistiani, S., Santikayasa, I. P., Taufik, M., & Lubis, R. F. (2024). Analisis Multitemporal Pengaruh Perubahan Penggunaan Lahan terhadap Klasifikasi Resapan Air Tanah di Kota Surakarta. Majalah Geografi Indonesia, 38 (1): 60-71.

[3] Muhammad Zuhdi, dan , Bakti Sukrisna. 2023. Metode Geolistrik Elektroda Schlumberger untuk Pemetaan Air Tanah di Kecamatan Sandubaya, Kota Mataram. Jurnal Penelitian dan Pembelajaran Fisika Indonesia. 5 (1): 31-35.

[4] Nurfalaq, A., Manrulu, R. H., Manrulu dan A. Jurmandi. 2022. Identifikasi akuifer air tanah menggunakan metode geolistrik konfigurasi Schlumberger untuk perencanaan sumur bor di Desa Barugae Kabupaten Pinrang. Jurnal Applied Physics of Cokroaminonto Palopo. Vol. 2 No. 1.

[5] Wahyuni, A., Erfan, dan Syamsuddin. 2019. Identifikasi Potensi Air Tanah Dengan Metode Geolistrik Konfigurasi Wenner-Schlumberger Di Daerah Pucak Kecamatan Tompobulu Kabupaten Maros. Makassar: Universitas Hasanuddin.

[6] Muhardi, R. Perdhana, dan Nasharuddin. 2019. Identifikasi keberadaan air tanah menggunakan metode geolistrik resistivitas konfigurasi Schlumberger. Jurnal Prisma Fisika. 7(3). 331-336.

[7] Massinai M.F.I., S. Bundan, M. A. Massinai., dan W. Hidayat. 2019. Tipologi sistem akuifer endapan gunungapi. Jurnal Geomine. 7 (2). 124-132

[8] Arsyad K. M. 2017. Modul geologi dan hidrologi pelatihan perencanaan air tanah. Kementerian PUPR, Bandung.

[9] Zuhdi, M. 2019. Buku ajar pengantar geologi. Mataram: Duta Pustaka Ilmu-Mataram.

[10] Nurwidyanto, M. I., M. Yustiana, dan S. Wiada. 2006. Pengaruh ukuran butir terhadap porositas dan permeabilitas pada batu pasir. Jurnal Berkala Fisika. 9 (4). 191-195.

[11] Usman, B., Manrulu, R. H., Nurfalaq, A., & Rohayu, E. 2017. Identifikasi Akuifer Air Tanah Kota Palopo Menggunakan Metode Geolistrik Tahanan Jenis Konfigurasi Schlumberger. Jurnal Fisika Flux: Jurnal Ilmiah Fisika FMIPA Universitas Lambung Mangkurat, 14(2), 65-72.

[12] Telford, W. M., Geldart, L. P. and Sheriff, R. E., 1990, "Applied Geophysics, Second Edition", Cambridge University Press, United State of America.

[13] Sulistijo, B., 2003. Peranan teknologi geofisika dalam memantau masalah lingkungan. Jurnal Teknik Pertambangan.