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Technical Guidance on Groundwater Identification to Overcome Drought in Tanamerah Village, Saronggi, Sumenep, East Java.

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ABSTRACT

Tanamerah Village is one of fourteen villages in Saronggi District, Sumenep Regency, East Java. Villagers experience water difficulties during both the rainy season and the dry season. Technical guidance will be carried out for groundwater identification to find out where the groundwater points are located that are able to meet the community's water needs. The method used for identification makes six tracks with varying distances between tracks. The length of each passage is twelve meters, and the depth of each passage is three hundred meters. Identification was carried out on village treasury land with an area of 500 m2. Six tracks in this service, the distance between tracks is 5-8 m, and the length of each track is 12 m. Track 1 was obtained from groundwater at a depth of 80m, and track 2 was obtained from groundwater at a depth of 80 m. Track 3 was obtained from groundwater at a depth of 70 m, and track 4 was obtained from groundwater at a depth of 20 m. Passage 5 is obtained from groundwater at a depth of 20 m, and passage 6 is obtained from groundwater at a depth of 70 m. Recommended drilling point is located on the TM1 line at point 8 with a depth of 80 m.

Keywords: *Drought, Groundwater, Identification, Technical Guidance, East Java.*

1. INTRODUCTION

The Sumenep district is located in the East Java province and comprises 27 sub-districts and 332 villages. It has an area of 2,093.47 km² and a population of 1,076,805. Tanamerah village is located in the Saronggi sub-district of Sumenep district, as shown in Figure 1. Tanamera village has a population of 3,298. Tanamera Village has limestone and clay soil, and is located in an area prone to drought. The area of East Java affected by drought increased by 3.69% from 2017 to 2018, with 22.24% of paddy fields affected in 2017 and 25.93% in 2018, most of which experienced moderate drought conditions [1]. Sumenep is categorised as being at high risk of drought, particularly during the dry season from August to October when rainfall is minimal [2]. The region's agricultural sector suffers crop failures due to a lack of water, which particularly affects smallholder farmers, who are already impoverished and have limited access to irrigation [3]. East Java experiences severe droughts exacerbated by climate change, with a strong correlation to El Niño events. The region's prolonged dry season and limited rainfall pose a significant threat to agriculture, necessitating effective mitigation and adaptation strategies for the sustainable management of water resources [4].

The geological formation in the Sumenep Regency is the Madura Formation. It partially overlaps with the Pasean, Bulu, and Ngrayong Formations in a conformable manner and in a non-conformable manner. It is estimated to be of Pliocene age. In the Lembar Tanjung Bumi-Pamekasan and Lembar Surabaya-Sapulu areas, however, it is Late Miocene-Pliocene in age. The Madura Formation consists of coral reef limestone and dolomitic limestone. Reef limestone is dense and generally has a porous surface, which is locally dolomitic. This rock unit varies from calcareous limestone and sandy limestone at the bottom to crystalline limestone and dolomitic limestone. Although geology significantly influences drought dynamics, it is important to consider that human activities, such as excessive groundwater exploitation, can exacerbate drought conditions, leading to severe water scarcity and ecological impacts. Based on the analysis of the current situation in Tanamerah Village, Suronggi Subdistrict, Sumenep, East Java, this research directly contributes to the community by providing technical guidance to identify sufficient clean water supplies for residents. Exploration of groundwater in karst-granite areas involves hydrogeological surveys to identify aquifer structures. This is followed by direct current electrical resistivity methods to confirm their characteristics. Ultimately, this leads to the successful drilling of boreholes with water yields that meet the study objectives [6]. Studies in the Kuningan and Simalungun regions indicate that the resistivity method can identify potential geothermal resources and subsurface structures related to groundwater [7].

These techniques have been used to analyze groundwater flow and aquifer depth, revealing potential recharge zones and suitable locations for borehole drilling [8]. Combining satellite remote sensing with geophysical data improves the identification of groundwater-rich areas and enhances the accuracy of groundwater detection [9]. Integrating geomagnetic methods for groundwater exploration reduces exploration uncertainty and costs [10]. Groundwater investigation technology improves drilling success by mapping potential groundwater zones, identifying suitable borehole locations, and reducing failure rates. This approach enhances access to drinking water, crucial for communities in drought-prone areas, ultimately increasing resilience to the impacts of climate change [11]. Groundwater investigation technology, through in situ monitoring, improves local drought assessment by providing accurate groundwater level measurements. This data enhances water availability estimates, enabling timely interventions and effective early warning systems to mitigate the impacts of hydrological drought in arid regions [12]. Resistivity methods have been successfully used to identify aquifers in drought-prone areas, such as Bima Regency, where two types of aquifers were identified at different depths [13]. Resistivity values indicate the presence of aquifers, which can provide groundwater sources to mitigate drought. In Banyol Hamlet, lower resistivity values in the tuff breccia layer indicate a potential aquifer, offering a solution to the drought problem [14]. Techniques such as electrical resistivity tomography and induced polarization provide insights into subsurface properties, aiding in the identification of groundwater resources and assessing water quality [15]. Time Domain Electromagnetic (TDE) methods enhance precision in locating groundwater extraction sites, especially in complex geological formations, by revealing hydrogeological structures and material composition [16]. Effective in complex terrain, TDE maps potential groundwater zones by analyzing subsurface electrical conductivity, identifying water-bearing geological materials [17]. In the Gunung Salak area, the correlation between the Active Directory Magnetotelluric (ADMT) method and Self-Potential reveals significant geothermal potential. Measurements show varying potential differences, indicating the presence of altered minerals and aiding in the identification of geothermal reservoirs [18].

2. METHODS

Data collection was conducted in June, a month when rainfall was deficient. Seasonal changes significantly impact the availability of groundwater, particularly during periods of low water. Studies show that summer is a critical season for groundwater levels, with dry summers causing a significant water deficit that cannot be offset by a wet winter. Studies using machine learning models highlight the importance of summer rainfall and temperature as key factors influencing groundwater levels. Studies in Indonesia demonstrate that groundwater availability is notably higher during the rainy season than during the dry season. Dynamic discharge analysis reveals a decline in groundwater levels due to reduced rainfall [20]. Data collection was conducted at the coordinates shown in Figure 1: 7° 6'46.78" S and 113°49'54.09" E.

Figure 1. Data Collection Location

The data collection method involves planning the trajectory of each predetermined point at a set distance. This tool's trajectory accurately assesses the impact of groundwater recharge and abstraction, which directly affects groundwater availability. This helps manage annual groundwater allocation, ensuring sustainable use and minimizing negative effects on aquifers and connected water flows. Thus, it maintains resource balance [21]. Data is collected using the AGR ADMT 300HT3, a device that employs Active Directory Magnetotellurics (ADMT) and Self-Potential methods. The device can detect depths up to 300 meters. The ability to detect groundwater depth significantly influences the assessment of groundwater availability because differences in estimated water table depth can lead to different conclusions about accessible groundwater areas. This impacts ecosystems, populations, and irrigation potential across regions [22]. Accurate monitoring of groundwater depth is essential for sustainable management of this resource because it directly relates to its availability. Improved random forest regression models enhance depth detection and aid in understanding groundwater storage dynamics [23]. By accurately assessing the impact of groundwater recharge and abstraction, this tool directly influences groundwater availability. It helps manage annual groundwater allocation, ensuring sustainable use and minimizing negative effects on aquifers and connected water flows. This maintains the balance of resources.

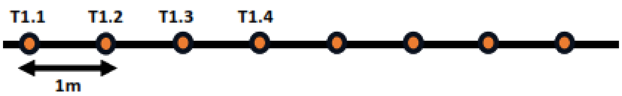

Figure 2. Pattern of Distance Between Data Collection Points

As shown in Figure 2, the distance between data collection points on each track is one meter. As shown in Figure 3, the distance between tracks is five to eight meters. Closer data collection points increase the model's spatial resolution, enabling better representation of hydrogeological features and recharge areas [24]. The spacing of data collection lines can significantly impact groundwater availability, particularly in regions where the interaction between groundwater and surface water is critical. Studies on groundwater modeling show that the spatial distribution of data collection points affects the accuracy of assessments of recharge and extraction rates of groundwater. This is particularly relevant in alluvial aquifers, where pumping groundwater can reduce river flow and alter hydrological dynamics [25].

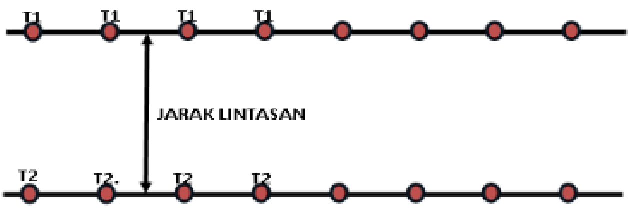

Figure 3. Pattern of Distance Between Data Collection Trajectories

There are six data collection tracks consisting of TM1, TM2, TM3, TM4, TM5, and TM6. The distance between tracks varies from 5 to 8 meters, as shown in Figure 4. The distance between points within a track is one meter.

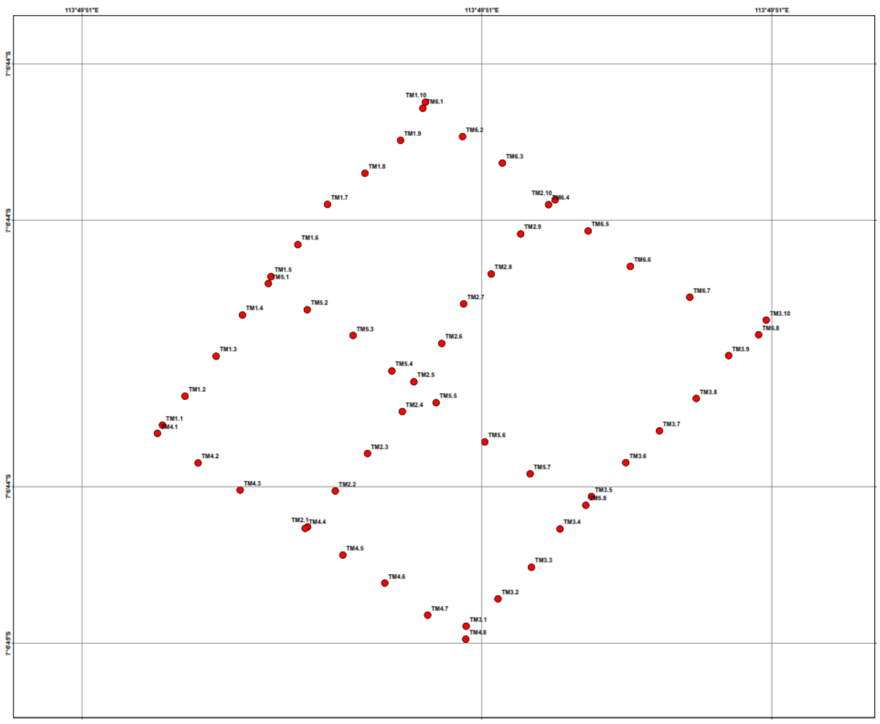

Figure 4. Data Collection Trajectory Map

3. RESULTS AND DISCUSSION

As shown in the Figure. 5, the northern border of Tanamerah Village is Nambakor Village, the southern border is Lobuk Village, the eastern border is Saroka and Langsar Villages, and the western border is Bluto, Saronggi, and Saronggi Villages. The Madura Formation partially overlaps the Pasean Formation in parallel and non-parallel manners. It also overlaps the Bulu Formation and the Ngrayong Formation. The Madura Formation is believed to be of Pliocene age. In the Tanjung Bumi-Pamekasan Sheet and the Surabaya-Sapulu Sheet, however, it is of Late Miocene-Pliocene age. The Madura Formation consists of coral limestone and dolomitic limestone. The coral limestone is compact and generally porous with dolomitic areas. This rock unit varies from calcareous limestone and sandy limestone at the bottom to oolitic limestone and dolomitic limestone. The formation was deposited in a shallow, calm marine environment and is approximately 250 m thick. Figure 6 shows the formation. The distance between tracks during data collection can be seen in Table 1. The distance between tracks is adjusted to the area of the data collection location.

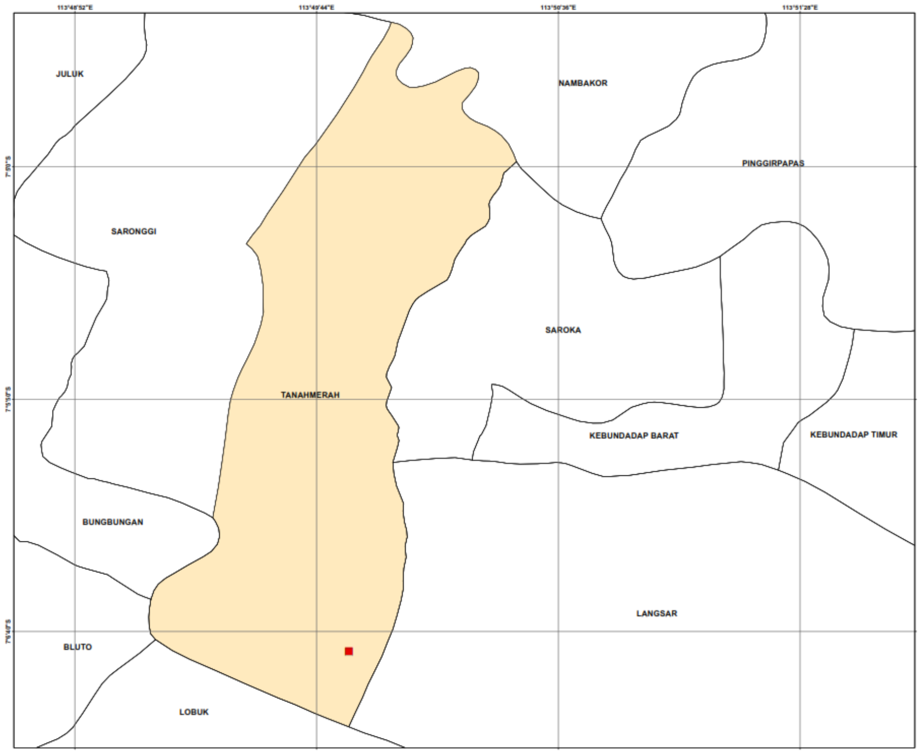

Figure 5. Administrative Map of Tanamerah Village

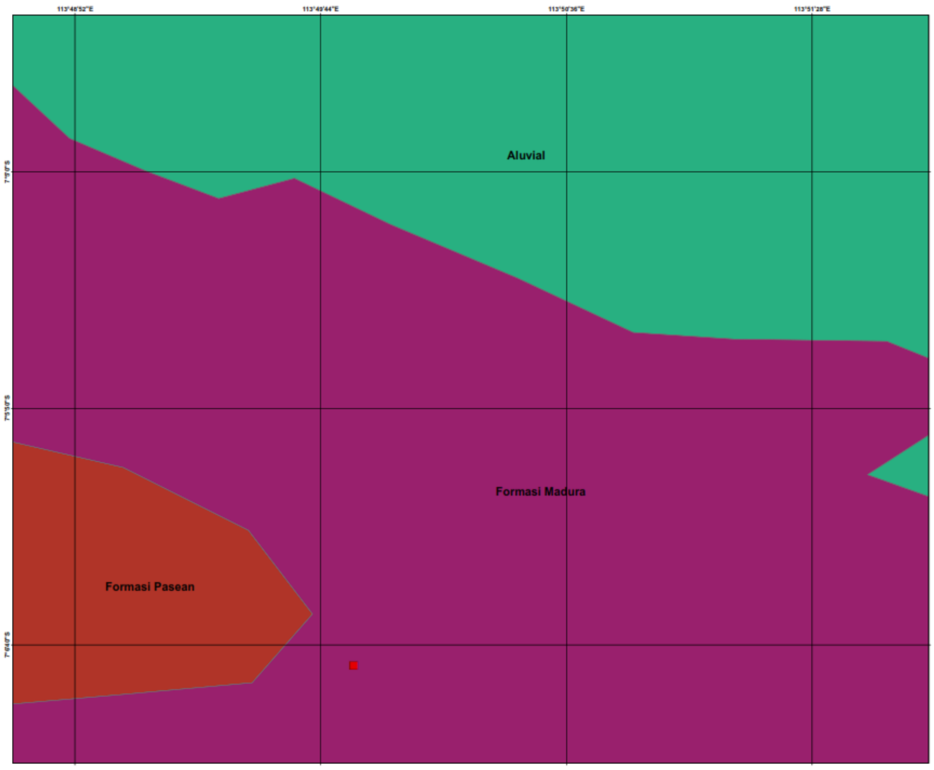

Figure 6. Geology Map

Table 1. Distance Between Tracks

No	Tracks	Distance (m)
1	TM1-TM2	5
2	TM2-TM3	5
3	TM4-TM5	8
4	TM5-TM6	8

Source

Figure. 7 shows the identification on the TM1 tracks. The top layer is topsoil, which is 20 m thick. The second layer is sand and gravel, which is 19 m thick and is found at a depth of 20–39 m. This layer is followed by a limestone layer, which is 29 m thick and is found at a depth of 39–68 m. The depth of 69–200 m is groundwater.

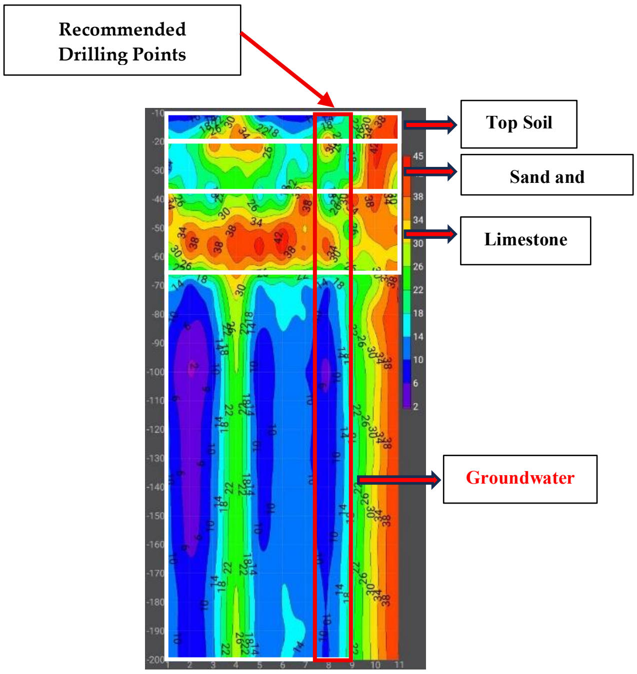

Figure 7. TM1 Tracks Identification Results

The TM 2 tracks is shown in Figure 8. The first layer is 30 m of sand and gravel. The second layer, which ranges in depth from 31 to 67 m, is limestone. Groundwater is present at depths between 68 and 200 meters, and the recommended drilling point is between the first and second layers. The layers on the TM 3 section can be seen in Figure 9, which shows that the first layer at a depth of 0-78 m consists of limestone. Groundwater on the TM3 section is found at a depth of 78-170 m between points 5 and 6 and at a depth of 109-170 m between points 1 and 2. Groundwater drilling is recommended between points 1 and 2 at a depth of 109-171 m. Data collection on the TM4 track identified groundwater at a depth of 0-43 m between points 1 and 6. Points 1 to 4 had groundwater at a depth of 73-128 m, and the layer on the TM4 track was mostly limestone. Recommended drilling points for groundwater drilling between points 1 and 2 at a depth of 80-119 m.

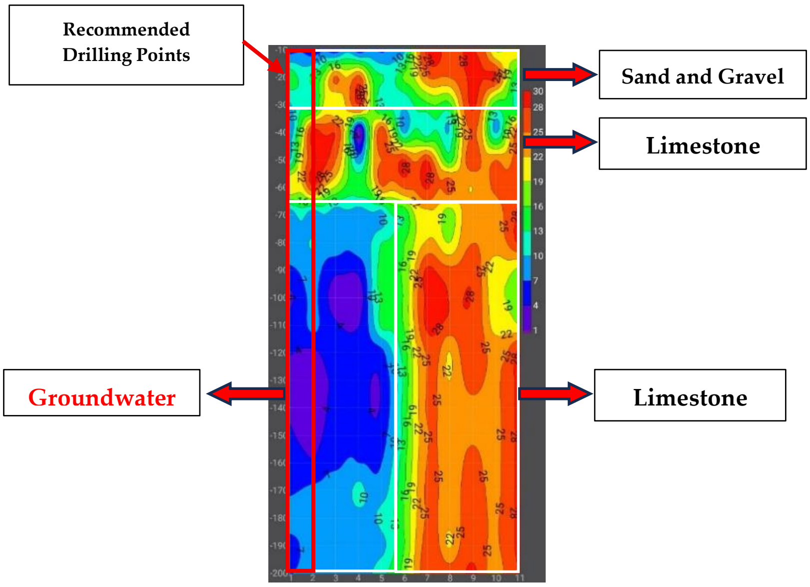

Figure 8. TM2 Tracks Identification Results

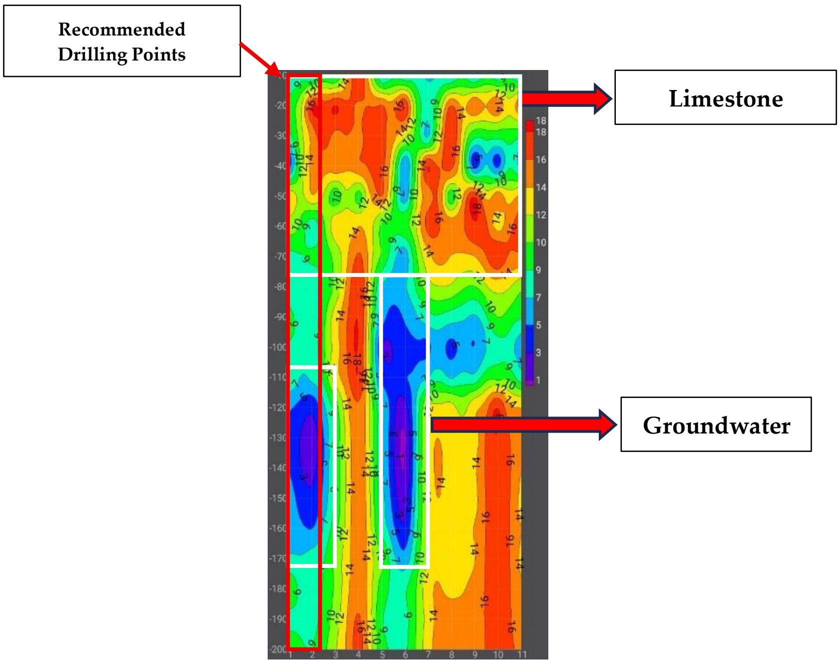

Figure 9. TM3 Tracks Identification Results

The TM5 section has two groundwater points, namely at a depth of 0-43 m at points 1 to 9, as shown in Figure 11. A depth of 69-125 m also identified a groundwater layer at points 1 to 4. The recommendation for groundwater drilling is at points 1 to 4 at a depth of 69-125 m. Groundwater was not identified along the TM6 section, as the soil layer is dominated by limestone, as shown in Figure 12.

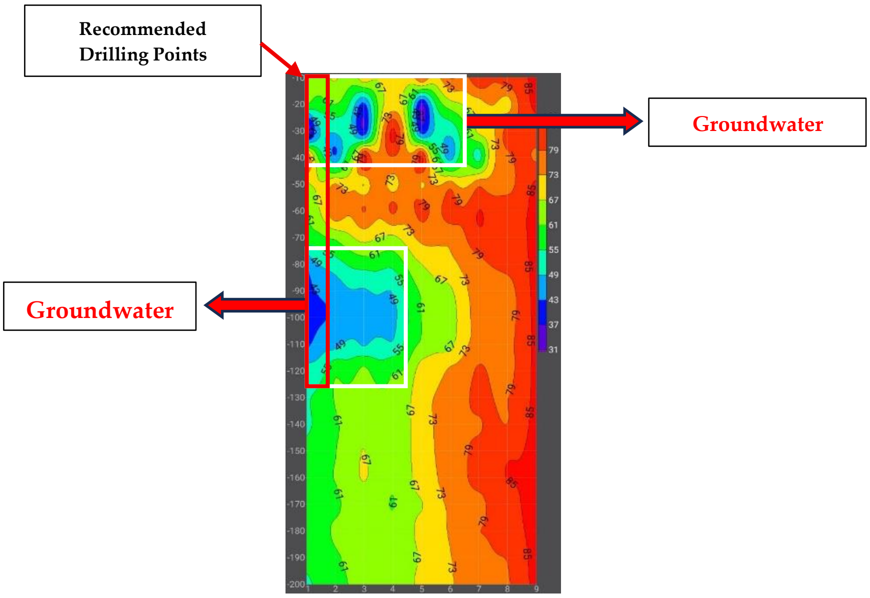

Figure 10. TM4 Tracks Identification Results

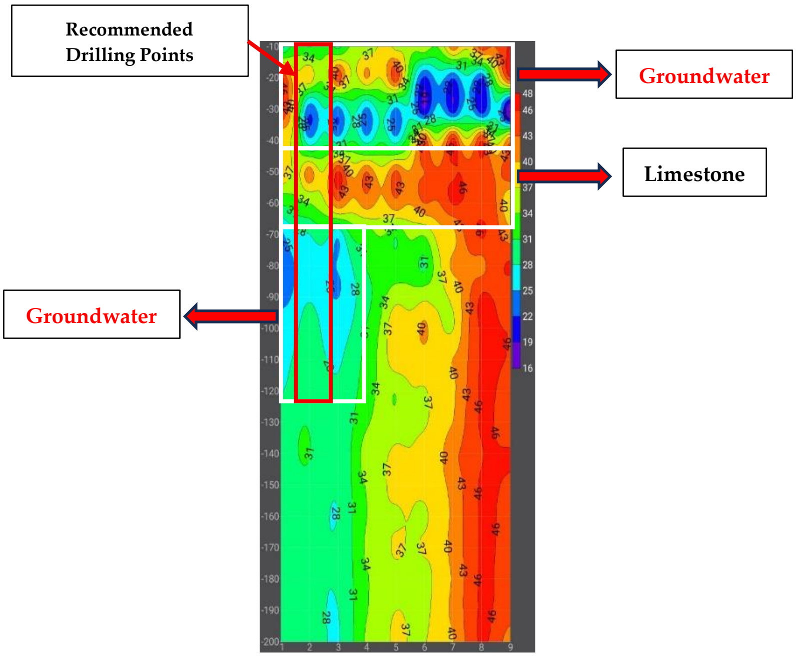

Figure 11. TM5 Tracks Identification Results

Identifying groundwater using the electromagnetic method involves measuring the electromagnetic radiation response to determine conductivity and inductance [26]. The groundwater identified along each survey line has low resistivity values ranging from 3 to 15 Ωm. These low resistivity values (2.82–11.72 Ωm) indicate high water content and suggest the potential for groundwater zones. Research findings correlate low resistivity with areas that tend to produce significant groundwater resources [27]. Resistivity values indicate the geological composition and water saturation of subsurface layers. Typically, lower resistivity values indicate higher water content, while higher values indicate less water presence. This aids in identifying potential aquifers and suitable drilling locations [28]. The geological structure in Tanahmerah Village is dominated by limestone, which is consistent with the geological formation of the area, the Madura Formation.

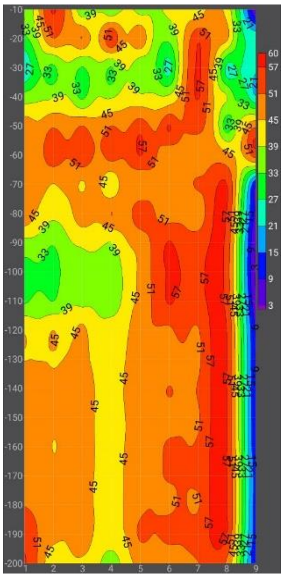

Figure 12. TM6 Tracks Identification Results

The Madura Formation includes various lithological units, such as breccia and pyroclastic fragments, which can influence subsurface permeability and porosity and thereby affect groundwater dynamics [29]. The geological complexity of the Madura Formation suggests the presence of multiple aquifer systems, including both confined and unconfined types. Interactions between these aquifers and geological structures can significantly impact groundwater availability. The TM1 and TM2 transects exhibit varying depths of groundwater potential. Groundwater was identified at depths of 69–200 m on the TM1 section at points 1 to 8.9, indicating significant groundwater potential, as shown in Figure 7. As shown in Figure 8, groundwater identification on the TM2 section indicates significant groundwater potential at depths of 68–200 m at points 1 to 6. The groundwater detected in TM1 and TM2 is deep groundwater stored beneath the limestone surface. The geological structure of the limestone, particularly karstic fractures, plays a role in this. The Zhangxia Cambrian Formation limestone exhibits weaker solubility than other formations, affecting its water content and the development of aquifers containing groundwater [30]. The recommended drilling point from the six routes for water availability in Tanamerah Village, Suronggi, Sumenep, East Java, is at route TM1, point 8, with a depth of 80 m.

CONCLUSION

Provide a statement of what is expected, as stated in the "Introduction" chapter. The conclusion of the community service technical guidance on groundwater identification in Tanamerah Village, Suronggi, Sumenep, East Java, based on the data obtained, is that the recommended drilling point is located on the TM1 line at point 8 with a depth of 80 m.

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