MUNICIPALITY OF SANTIAGO

GEORESISTIVITY SURVEY AT THE PROSPECTIVE WELL SITE AT RIZAL, SANTIAGO CITY

FEBRUARY 17, 2025

Prepared by SWIM Project 1
Isabela State University – Echague
San Fabian, Echague, Isabela

HYDROGEOLOGICAL OBSERVATION

PHYSIOGRAPHY

The land area of Santiago is approximately 316 km2. Its terrain varies across the region with relatively flat areas dominating the southeastern and central parts which are more suitable for infrastructure and agriculture. The northwestern part of Santiago city exhibits the undulating part or the mountainous region. The slope values range from nearly flat (1.44°) to steep (53.17°), suggesting the presence of hilly or mountainous regions.

LOCAL GEOLOGY

The geology of Santiago city was provided by the Mines and Geosciences Bureau. It is characterized by a mix of marine and terrestrial sediments associated with limestones with pyroclastic materials and gravel deposits. This indicates that the area has experience sedimentary and volcanic influences over geological time. Additionally, the presence of pyroclastic deposits, which are volcanic materials Indicates past volcanic activity that contributed to the city's geological makeup.

GEOLOGIC STRUCTURE

There are no perceptible geologic structures that could significantly affect the groundwater storage and flow. The only identifiable features and structures are found in the uppermost most of the soil and wells extending on the saturated zone or aquifer.

GEORESISTIVITY SURVEY

PRINCIPLES

Resistivity is a geophysical surveying technique that utilizes electrical measurements conducted on the ground surface to identify the depth and thickness of subsurface resistivity layers. In groundwater investigations, resistivity surveys help improve the understanding of underground formations and reduce the likelihood of drilling unsuccessful wells.

Since soil and rocks generally act as electrical insulators with high resistance, electrical currents primarily pass through moisture-filled pore spaces. The resistivity of these materials is influenced by factors such as porosity, permeability, the amount of pore water, and the concentration of dissolved solids. Various soil and rock types exhibit different resistivity values depending on their composition, texture, degree of fracturing or weathering, and groundwater content. This method involves injecting a known and often constant electrical current into the ground using two electrodes, called current electrodes. This process generates a potential field (voltage), which is then recorded through another pair of electrodes known as potential electrodes. The resistance obtained from these measurements is adjusted using a geometric factor to calculate the apparent resistivity.

Resistivity surveys can be conducted to analyze the sequence of resistivity layers beneath a specific location, a technique known as vertical electrical sounding (VES). The resistivity values obtained are then interpreted to determine the possible types of rock present below the surface.

SURVEY DETAILS

A vertical electrical sounding (VES) was carried out during the resistivity survey inside the vicinity of ISU Santiago Extension with geographic coordinates of 16.7226 latitude and 121.5261 longitude. The soundings were performed using the Schlumberger configuration and carried out with the maximum diameter of 72 meters. This laying distance permit an effective penetration of 50 meters underground. The team utilized a software called Terrameter LS Toolbox to extract and analyze the data gathered during the survey from the VES.

The file GeoVES Punjab VES was used as the dataset for interpretation. This file contains formulas and measurements, including electrode spacings and corresponding resistivity values. The data was analyzed to determine subsurface layer characteristics such as resistivity, thickness, and depth. The extracted data was processed to generate resistivity curves, which were then compared to known geological models.

LOCATION

The survey site is located at Isabela State University Santiago Extension Rizal, Santiago city.

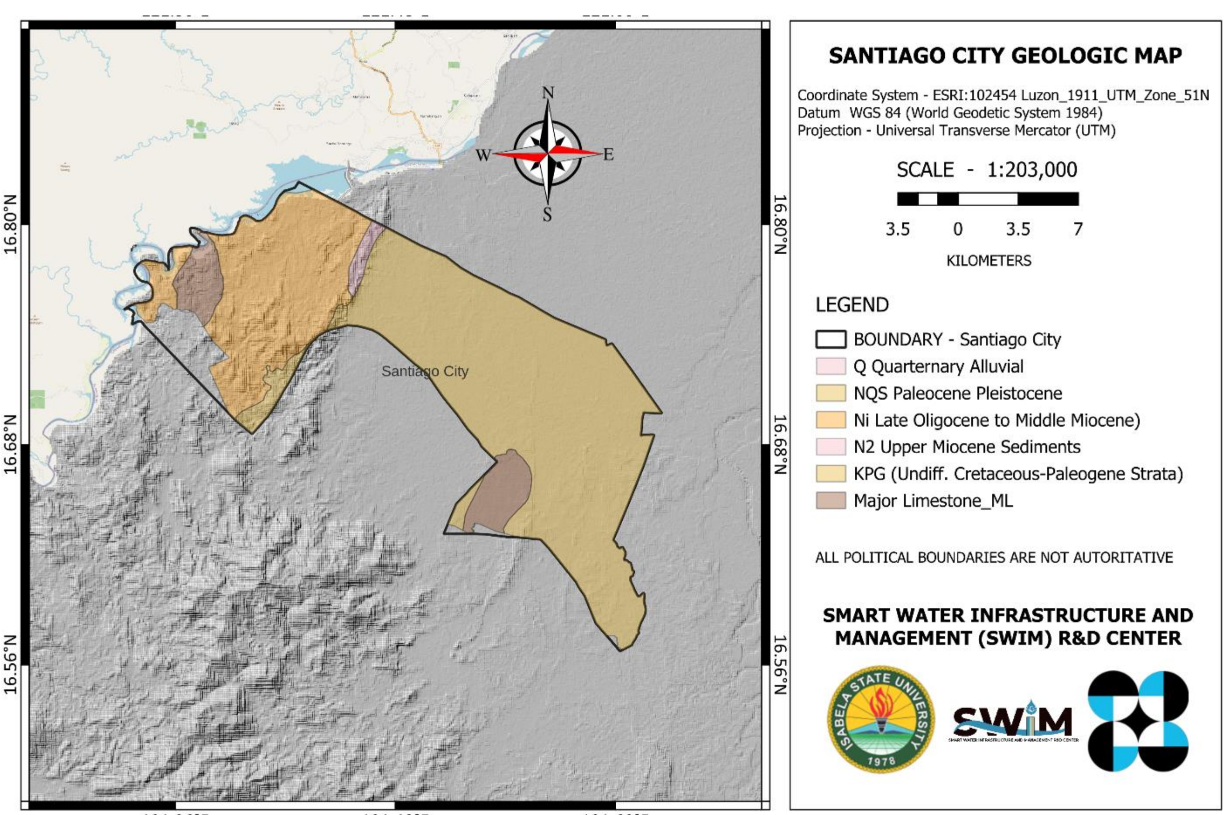

Figure 2. Geologic Map of Rizal, Santiago City

Site Description

Figure 3. Survey Area

Given the dark, fine-textured soil and relatively flat terrain, the underlying rock formations are likely composed of shale, siltstone, or mudstone, which weather into fine particles. The soil type appears to be clay loam or silty clay based on its dark color, moist texture. The soil's condition suggests it retains moisture well, making it suitable for crop cultivation. The field is relatively flat, with no noticeable elevation changes, indicating a lowland topography ideal for farming operations.

Table 1. Possible lithology values based on resistivity values according to literature

Classification	Resistivity Values (ohm-m)
Clayey Alluvium or Mudstone	1-10
Silty Alluvium or Siltstone	10-40
Sandy Alluvium or Sandstone	40-500
Rocks with saline groundwater	<1

RESULTS

Table 2 shows the apparent resistivity values obtained during the survey which presents the AB/2 electrode spacing, measured apparent resistivity, modelled apparent resistivity in terms of ohm-m, and model error. The measured apparent resistivity values vary with electrode spacing having a decreasing trend overall. The highest measured apparent resistivity is 55.9 ohm-m at 1 m spacing indicating a coarsegrained-sediments and a dry layer. The lowest measured apparent resistivity is 25.2 ohm at electrode spacing of 72 meters suggesting a water saturated zones.

Table 2. Apparent Resistivity Values obtained

AB/2 (m)	Measured Apparent Resistivity (Ohm-m)	Modelled Apparent Resistivity (Ohm-m)	Model Error	Included in Model (1=yes)
1.0	55.9	46	90	1
1.4	37.1	37	0	1
1.9	29.2	31	4	1
2.7	30.8	30	0	1
3.7	34.7	33	4	1
5.2	38.6	36	5	1
7.2	40.9	39	4	1
5.2	38.3	36	3	1
7.2	40.0	39	1	1
10.0	38.2	39	1	1
14.0	35.8	37	2	1
19.0	30.4	34	15	1
27.0	27.7	31	11	1
37.0	26.4	28	4	1
27.0	30.4	31	0	1
37.0	29.1	28	1	1
52.0	28.2	26	6	1
72.0	25.2	24	3	1

Figure 4 shows the georesistivity curve that shows the of apparent resistivity (Ωm) as a function of electrode spacing (AB/2, in meters). The plot is on a log scale where the circles represent the measured resistivity values and the red line presents the modeled resistivity curved from the data. The apparent resistivity values decrease initially, followed by slight fluctuations, and then a gradual decline as the electrode spacing increases. This indicates that each layer has a different electrical resistivity due to different material composition. The higher resistivity values at small AB/2 suggest the presence of shallow more resistive materials, possibly compacted soil or unsaturated zones. Lower resistivity values at greater depths suggest water-saturated layers which are known to reduce resistivity.

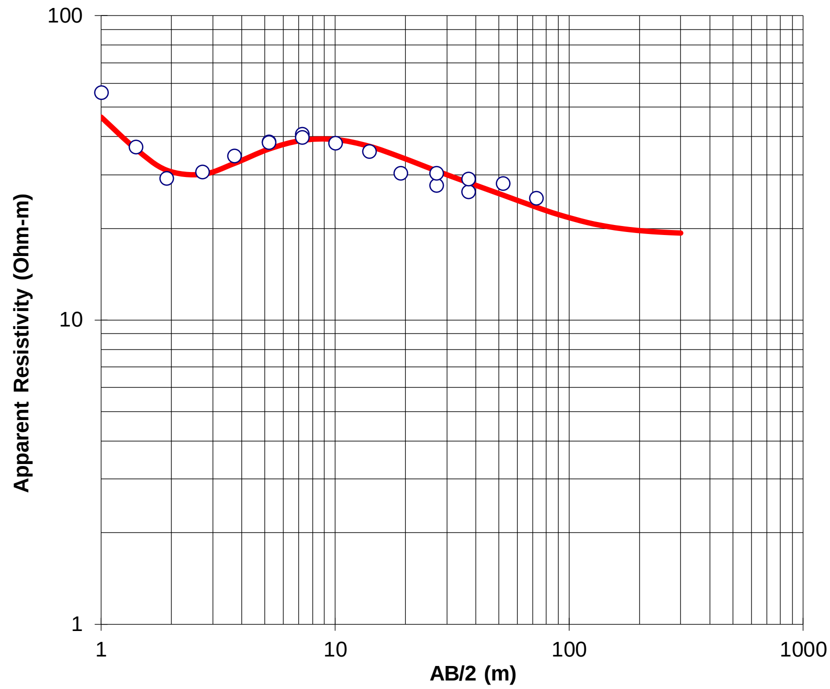

Figure 4. Georesistivity Curve Showing Apparent Resistivity Variation with Electrode Spacing (AB/2)

Table 3 presents the georesistivity model parameters, which include the resistivity (Ohm-m), thickness (m), and depth (m) of different subsurface layers. These parameters are important in understanding the hydrogeologic and water availability of the surveyed area. The first layer with a depth of 0.5 m has a resistivity of 70 ohm-m suggest that it is dry and compacted. The second layer with a depth of 1.68 has a resistivity of 20 ohm-m indicates that the presence of water is high, however, it is not deep enough to be considered an aquifer. This could be due to soil moisture or a perched water table. 3rd layer shows a resistivity of 58 ohm-m with a depth of 5.18 meters suggest the soil has resistivity value indicating that the potential presence of water is low. The fourth layer is the thickest at 24 m represent a dominant geologic formation, it has a resistivity value of 28 ohm-m with a depth of 29.18 meters. This indicates the potential groundwater presence is high and its depth of extent make it likely to be classified as an aquifer.

Table 3. Georesistivity Model Parameters Showing Resistivity, Thickness, and Depth of Subsurface Layers

Model Parameters									
Model Layer	Resistivity (Ohm-m)	Resistivity Range		Thickness (m)	Thickness Range		Depth (m)	Depth Range	
1	70	10.34	11.55	0.5	0.92	1.09	0.5	0.92	1.09
2	20	24.5	25.75	1.18	8.19	10.44	1.68	8.69	10.94
3	58	17.64	18.36	3.5	66.5	74.9	5.18	68.18	76.58
4	28	31.68	33.99	24			29.18		
5	19			10			39.18		

EVALUATION AND RECOMMENDATIONS

The underlying rock formation of the surveyed area likely composed of shale, siltstone, or mudstone. The soil's condition suggests it retains moisture well, making it suitable for crop cultivation. Based on the Vertical Electrical Sounding (VES) survey carried out, it is suggested that the drilling should be more than 29 meters as it yields low resistivity value indicating the potential groundwater presence is high. Its layer thickness is 24 meters which is the thickest among the layers indicating a higher capacity for water storage. While water presence is observed at shallow depths (1.68 m), the thin layer suggests it is not a reliable aquifer.

Furthermore, since the survey was carried out during the rainy period where the groundwater level is high, it is suggested that only 1 well to be constructed as its water level, pH, and chloride content be regularly to monitored. The data to be collected will be the basis to determine the optimum depth and limit of the parameters.

DOCUMENTATION

Photo 1. Preparation of the Vertical Electrical Sounding (VES) instrument at the survey site

Photo 2. Laying out of wires and rods using the Schumberger Electrode array for georesistvity survey

Photo 3. Survey site in ISU – Santiago Extension Campus Rizal, Santiago City

Photo 4 University President, Prof. Ricmar P. Aquino, Dr. Melito Mayormente, Campus Coordinator, sir Jonathan of LGU Santiago, and SWIM Center staffs