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Coupling geophysics and granulometry for the siting of high-flow boreholes in a sedimentary environment

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ABSTRACT: The Cotonou and agglomerations drinking water supply project is located in the District of Ouédo (commune of Abomey-Calavi). In this area, the water supply has become insufficient, due to urbanization and the deterioration of hydraulic infrastructure. An establishment of high-flow drilling by electrical surveys and brief particle study was thus undertaken. Five geological layers, whose resistivities and thicknesses varying respectively from 31.95 to 872.12 Ω.m and between 1.99 to 244.5 m are highlighted. Three aquifers lying between 60 and 114 m deep are revealed. These aquifers are formed of coarse elements with a diameter greater than one mm. A catchment field of sixteen boreholes, each providing a high flow rate (100-250 m3/h), was carried out. This one mobilized an overall flow of 2680 m3/h (i.e. 64,320 m3/d). This flow has contributed to the achievement of more than 60 % of the Millennium Development Goals development in terms of drinking water by Benin.

KEYWORDS: aquifer, electrical survey, particle size, recognition survey, flow.

1 INTRODUCTION

Since the Water Decade and with a view to achieving the Millennium Development Goals (MDGs), the Beninese government, like other African countries, has made considerable efforts to improve access to drinking water in both rural and urban areas [1]. In 2005, the service coverage rate in cities was around 51% [2]. As part of the Growth Strategy for Poverty Reduction, implemented from 2011 to 2015, the Beninese government identified improving access to drinking water as one of its most important challenges and made efforts to increase the coverage rate [3].

As in all capitals of countries south of the Sahara, the concentration of economic infrastructure has led to rapid expansion of the city of Cotonou and its suburbs, which are attracting increasing numbers of people [4]. In addition, Cotonou and its suburbs are supplied with drinking water from the Godomey catchment area, which is increasingly threatened by saltwater intrusion [5]. As a result, the drinking water supply rate has become insufficient given the high rate of urbanization and the deterioration of water supply and distribution infrastructure [5]. The coverage rate in urban areas rose from 50% in 2005 to 58.52% in 2010, but still only covers 55% of Cotonou's needs and 20% of its outlying neighborhoods [2]. In other words, the water needs of the study area have been estimated at 2,820 m^3/h [4]. To meet these needs, a major project to strengthen the drinking water supply system in Cotonou and its suburbs has been implemented. It plans to increase production capacity to 105,350 m^3/day, representing 75% coverage in 2015, by installing a field of high-yield boreholes in the Ouédo district. This new field will complement the Godomey fields, while eliminating the risk of saline intrusion. To achieve this, a study combining the geophysical methods of electrical resistivity and granulometry was conducted.

2 Presentation Of The Study Area

The city of Cotonou is located at the intersection of parallels 6°20 and 6°24 north latitude and meridians 2°20 and 2°29 east longitude. It is located at the southern tip of Benin, on the Atlantic coast. It is made up of several municipalities, including Abomey-Calavi. Ouédo is one of the districts of this municipality and is bordered to the south by the district of Hévié, to the north by the district of Glo-Djigbé, to the east by the municipality of Tori-Bossito, and to the west by the district of Togba (Fig. 1).

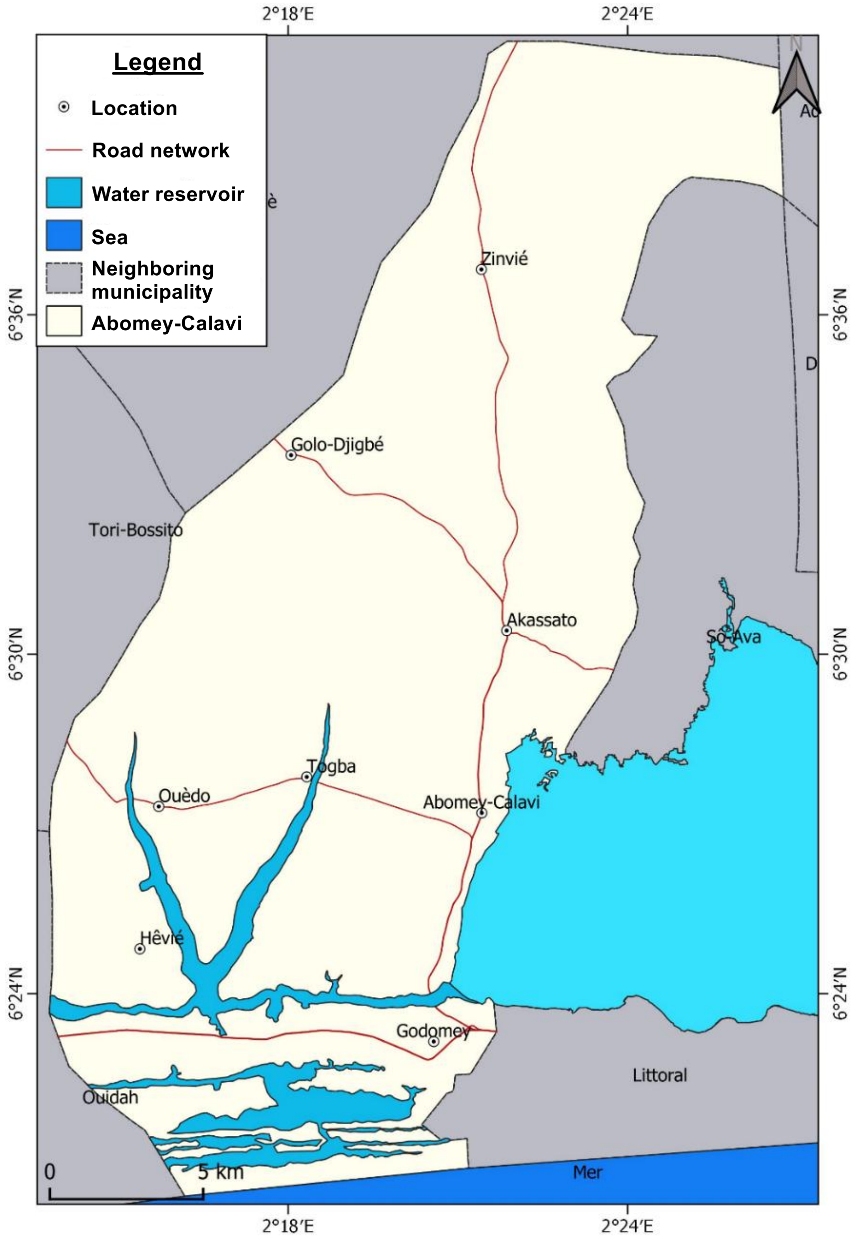

Fig. 1. Map of the study area

It is in this district that work has been carried out to reinforce the catchment area (drilling and equipping of production wells) with a view to supplying drinking water to Cotonou and its suburbs.

3 Materials And Methods

3.1 Equipment

A SYSCAL resistivity meter (Fig. 2) was used to measure electrical resistivity in the field. The accessory equipment consists of a 12 V car battery, electrical connection wires (2 rolls of 200 m and 2 rolls of 400 m), metal electrodes, portable radios, etc.

***Fig. 2.** Photo of a SYSCAL resistivity meter*

The granulometric measurements were performed using three (3) types of SAULAS brand sieves with respective diameters of 1 mm, 2 mm, and 3 mm (Fig. 3b). Fig. 3 shows photos of the sieves used and the samples collected and placed in boxes designed for this purpose (Fig. 3a). Samples are collected every 1 m as drilling progresses.

***Fig. 3.** Equipment used for particle size measurements: a) boxes containing soil samples taken during drilling; b) sieves used for particle size analysis*

The accessory equipment consists of a bucket to hold the water used to wash the samples to be measured, syringes for sampling and measuring the volume of the samples, funnels for pouring the sand grains into the syringes for reading, a notebook and a pen for recording the measured values.

It should be noted that the equipment used to process electrical resistivity data consists of charts (CH1 and auxiliary charts A, K, H, Q) and Qwseln software from the geophysics laboratory at the University of Paris VI. As for the processing of granulometric data in the field, this was done using graph paper, a pencil, an eraser, and a ruler. The granulometric curves were plotted using Excel.

3.2 METHODS

3.2.1 ACQUISITION OF ELECTRICAL RESISTIVITY DATA

The geophysical method used is the electrical resistivity method. It is based on measuring the resistivity of geological formations. This method involves transforming the input voltage supplied by a 12 V battery into a higher voltage, which is then applied to the ground via the AB current electrodes. This promotes the flow of a current of known intensity I between the two current electrodes. The voltage is collected at the terminals of two other electrodes (potential electrodes MN) to calculate the resistivity of the ground.

In this study, only the electrical sounding technique was applied. This technique is implemented using the Schlumberger device. In this symmetrical device, electrodes A, B, M, and N are aligned, with MN very small and centered relative to AB. It is characterized by a half-length AB/2 varying from 1 m to 400 m, with couplings between AB/2= 3 m and AB/2= 4 m, AB/2= 20 m and AB/2= 24 m, AB/2=55 m, and AB/2=60 m, and between AB/2=100 m and AB/2=130 m.

3.2.2 ACQUISITION OF GRANULOMETRIC DATA

Following electrical surveys, mechanical surveys were carried out, on the basis of which a granulometric study was conducted. The granulometric study, or granulometry, is a set of laboratory techniques used to determine the physical, petrographic, and geochemical characteristics of loose rocks [6]. The purpose of this work is to measure grain diameters. It consisted of taking a sample of drilling cuttings in a syringe of known volume. The sample was then sieved with water on three (3) sieves with diameters of 1 mm, 2 mm, and 3 mm. The first wash was carried out by pouring the entire volume of the first syringe onto the 1 mm diameter sieve. After washing, the second syringe was filled using the funnel and the volume measured. Pour this volume onto the 2 mm diameter sieve and proceed with the second wash. If there is no rejection for this sample, move on to the next one. But if there is a rejection, pour it back into the second syringe, measure it again, and note its value. Finally, repeat the same process on the third sieve with a diameter of 3 mm. The samples taken from each meter of the reconnaissance survey are thus sieved, except for those from areas consisting of compact clay. In sedimentary areas, such as our study area, we are interested in aquifers consisting of coarse sand. A more detailed description of the different sand particles is provided in Table 1 below.

Table 1. Detailed classification of sand particles

Particle	Different classes of sand particles
Sand	Particles between 0.063 mm and 2 mm in diameter
	Very coarse sand: 1–2 mm
	Coarse sand: 0.5–1 mm
	Medium sand: 0.25–0.5 mm
	Fine sand: 0.125 - 0.25 mm
	Very fine sand: 0.063–0.125 mm

3.2.3 INTERPRETATION OF ELECTRICAL RESISTIVITY DATA

The processing of electrical resistivity data is carried out in two stages: first manually, then digitally.

Manual interpretation required the use of the CH1 chart and auxiliary charts (LCD). Using the CH1 chart, the thickness h1 and resistivity ρ1 of the first soil layer and the ratio (ρ2) /ρ1 are determined. This ratio is used to deduce the true resistivity ρ2 of the second layer. The auxiliary tables are used to identify the characteristics (true resistivity ρ and thickness h) of each underlying layer.

The principle of digital processing of survey data is based on a terrain model consisting of several layers. In this work, the models resulting from manual processing (tables) are entered into the software. The software then plots the curves corresponding to these models. To improve these models, the software's results optimization function was used. This function tests several models and determines the one that is closest to both the measurements and the input model, which has a low margin of error.

Interpretation of this model leads to the location of aquifers, based on the true resistivity of the different superimposed layers. It also indicates their thickness and therefore their depth.

3.2.4 Interpretation Of Grain Size Data

The purpose of grain size analysis is to determine the productive horizons of mechanical boreholes in order to define the appropriate technical equipment for the structure. The grain size graphs were produced using Excel. The "grain diameter - sampling depth" data pair is plotted on semi-logarithmic paper, where:

- the grain diameters expressed in mm, determined by the mesh sizes of the sieves, were plotted on the x-axis on a logarithmic scale;
- the depths in meters (m) of the mechanical drilling were plotted on the y-axis on an arithmetic scale.

3.2.5 Method For Selecting The Depth Of Drilling To Capture High Flow Rates

A granulometric analysis was performed on the samples to determine the productive horizons.

Thus, on the semi-logarithmic graph, the aquifer zones were identified, which will be captured using screened casings placed in relation to them. The aquifer layers were areas with more than 20% of elements larger than 1 mm, which correspond to coarse sands.

Based on this preliminary work, a high-yield drilling site was selected based on a combination of the following parameters:

- the average resistivity value in the deep parts of the boreholes: the higher this value, the more resistant the deep layers are and therefore the more likely they are to store water;
- the lithology, which is the nature of the rocks (geological formations) making up the different layers of the subsoil;
- the size of the constituent elements of the subsoil, with more than 20% of elements larger than 1 mm;
- and the thickness of the geological formations (sedimentary deposits, sand, gravel, etc.).

These observations indicate that the area is suitable for drilling.

4 Results

4.1 Electrical Surveys

The results of the interpretation of surveys SE10, SE06, SE12, and SE03 obtained from the charts (CH1 and auxiliary) are recorded in Table 2.

Table 2. Results of the interpretation of surveys based on charts

Reconnaissance surveys								
Survey / Layers	SR01 (SE10)		SR02 (SE06)		SR03 (SE12)		SR04 (SE03)	
	Res. (Ω.m)	Thick. (m)	Res. (Ω.m)	Thick. (m)	Res. (Ω.m)	Thick. (m)	Res. (Ω.m)	Thick. (m)
Layer 1	620	1.80	150	0.30	182	0.30	750	2
Layer 2	434	34.00	600	47.50	564	74.90	600	5
Layer 3	220	243	540	172	420	72.25	750	80
Layer 4	660	182	230	-	126.3	-	625	104
Layer 5	240	-					350	-

These results show that the most stratified soils have five (5) layers and the least stratified soils have four (4) layers. Analysis of reconnaissance surveys SR01 (SE10) and SR04 (SE03) shows soils with five (5) layers. The resistivities of layers 1, 2, and 4 of SR01 (SE10) are relatively high, ranging from 434 to 660 Ω.m. They are less conductive than the other two (layers 3 and 5). The thicknesses of the layers of SR01 (SE10) are respectively h1= 1.80 m, h2= 34 m, h3= 243 m and h4= 182 m. In the SR04 (SE03) reconnaissance survey, the first four layers have relatively high resistivities (600-750 Ω.m) and are therefore less conductive than the fifth layer (350 Ω.m). These four layers have thicknesses of h1= 2, h2= 5, h3= 80 and h4= 104 m, respectively.

Reconnaissance surveys SR02 (SE06) and SR03 (SE12) reveal terrain with four (04) horizons. These surveys show low true resistivity values for the first and last layers. The two intermediate layers (layers 2 and 3) have high true resistivities ranging from 540 to 600 Ω.m and from 564 to 420 Ω.m, respectively, for surveys SR02 (SE06) and SR03 (SE12). These two layers are therefore less conductive than the first layers. Layer 3 is the thickest in survey SR02 (SE06) with a thickness of 172 m. The thicknesses of layers 1 and 2 are estimated at h1= 0.30 m and h2= 47.50 m. For borehole SR03 (SE12), the true thickness of layer 1 is 0.30 m, while layers 2 and 3 are 74.90 m and 72.25 m thick, respectively.

These models were then digitally processed to refine the interpretations. Thus, the interpretation of models derived from the processing of electrical survey data SE10, SE06, SE12, and SE03 made it possible to construct four survey curves (Fig. 4).

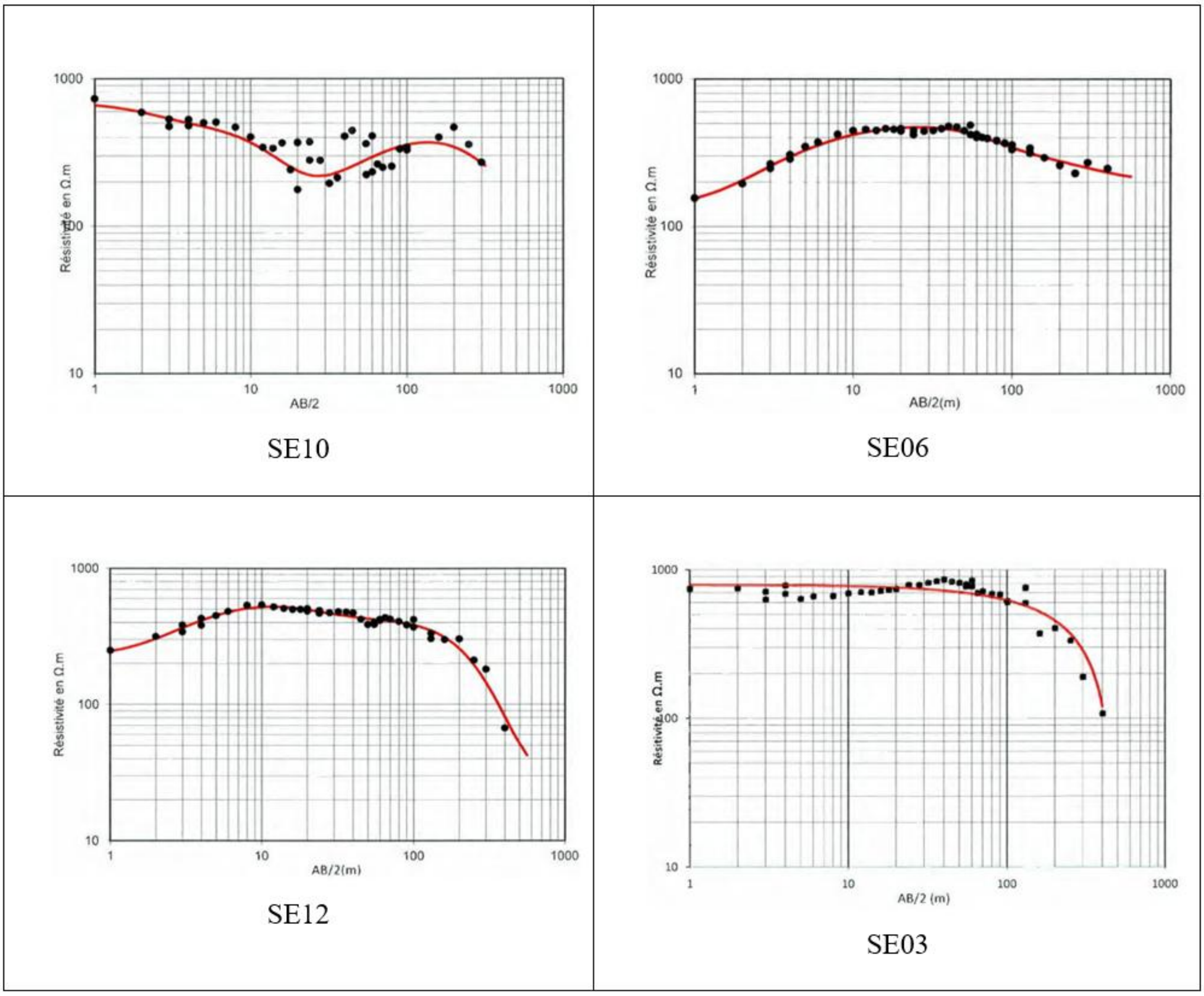

Fig. 4. Electrical survey curves

The true resistivities and thicknesses of the layers that make up the surveyed terrain are summarized in Table 3.

Analysis of the SR01 (SE10) reconnaissance survey gives an improvement deviation of 0.214. The resistivities of layers 1, 3, and 4 are higher than those of layers 2 and 3 and range from 300 to 600 Ω.m. Those of layers 2 and 5 are less than 300 Ω.m. The first and second layers are 3.62 m and 32.87 m thick, respectively. The third and fourth layers are 244.5 m and 179 m thick, respectively.

Table 3. Results of the interpretation of the surveys using Qwseln software

Reconnaissance surveys								
Survey / Layers	SR01 (SE10)		SR02 (SE06)		SR03 (SE12)		SR04 (SE03)	
	Res. (Ω.m)	Thick. (m)	Res. (Ω.m)	Thick. (m)	Res. (Ω.m)	Thick. (m)	Res. (Ω.m)	Thick. (m)
Layer 1	589.1	3.62	81.41	0.49	159.4	0.42	733.96	1.99
Layer 2	253.2	32.87	482.2	41.28	467.2	58.04	618.66	5.00
Layer 3	372.2	244.5	235.7	151.7	368.4	64.90	872.69	60.27
Layer 4	635.7	179.0	214.8	-	31.95	-	272.12	67.51
Layer 5	236.6	-					77.93	-

Reconnaissance Survey SR02 (SE06) indicates a thickness of 0.49 m and a resistivity of 81.41 Ω.m for the first layer. The resistivity of the second layer is the highest (482.2 Ω.m) and extends over 41.28 m. The third layer has a resistivity of 235.7 Ω.m and a thickness of 151.7 m. The resistivity of the last layer is 214.8 Ω.m. The values have been improved with a deviation of 0.056.

The analysis of the SR03 (SE12) Recognition Survey shows a thickness of 0.42 m and a resistivity of 159.4 Ω.m. The second and third layers have the highest resistivities (467.2 and 368.4 Ω.m). Their respective thicknesses are 58.04 and 64.90 m. The fourth layer has the lowest resistivity (31.95 Ω.m). For the SR04 (SE03) reconnaissance survey, the first three (3) layers have thicknesses of 1.99 m, 5 m, and 60.27 m, respectively, and high resistivities (733.96, 618.66, and 872.69 Ω.m). The last two layers have low resistivities of less than 300 Ω.m. These resistivity values are 272.12 Ω.m and 77.93 Ω.m, with a thickness of 67.51 m for the fourth layer Ω.m.

These different geophysical layers were then characterized in terms of grain size in order to identify probable aquifers.

4.2 Analysis Of Granulometry Results

The grain size distribution of reconnaissance borehole SR01 (SE10) shows that the coarse elements obtained with the 1 mm diameter sieve are fairly evenly distributed over almost the entire depth of the borehole (Fig. 5).

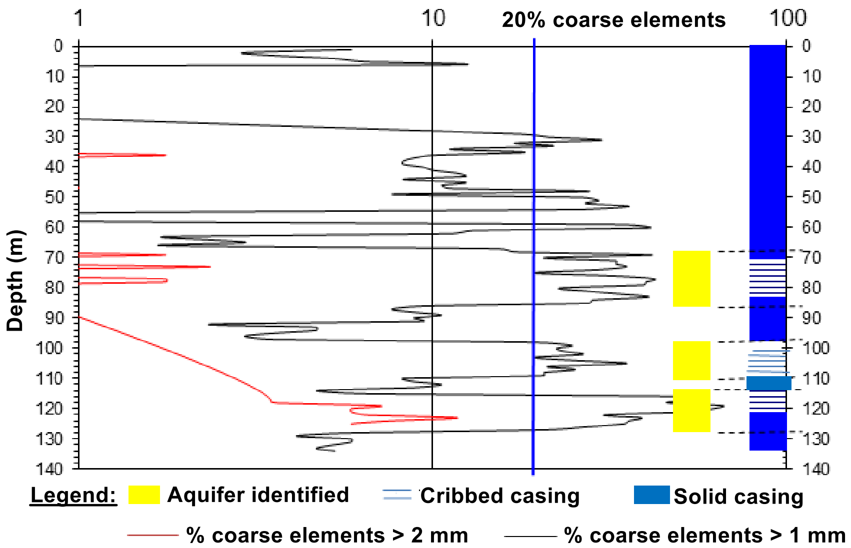

Fig. 5. Grain size distribution curve for reconnaissance borehole SR01 (SE10)

The percentage of these coarse elements varies (1%, 10%, 60%, etc.) and reaches 80% at a depth of 120 m. Coarse elements with a diameter of d=2 mm appear at a depth of 90 m and peak at 120 m. They also appear in a sawtooth pattern between 68 m and 78 m. They are also found slightly higher up, between 36 m and 38 m. However, sand particles with a diameter of d=3 mm were not identified anywhere throughout the mechanical drilling.

This granulometric analysis revealed three (3) aquifer layers: the first layer, 18 m thick, is located between 68 m and 86 m; the second layer (12 m) is between 98 m and 110 m; and finally, the third layer (14 m) extends from 114 m to 128 m. Another aquifer layer could have been identified between 35 and 40 m, but this was disregarded for technical and pollution reasons.

The grain size analysis of reconnaissance borehole SR02 (SE06) indicates that coarse elements (d=1 mm) are only present from a depth of 5 m downwards, and this is true for the entire depth of the borehole (Fig. 6).

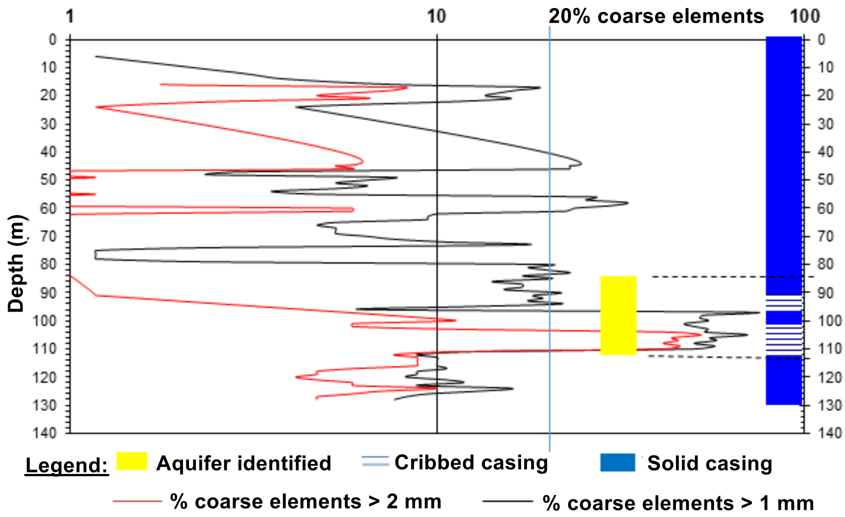

Fig. 6. Grain size curve for reconnaissance borehole SR02 (SE06)

The proportions of elements vary between 1.5 and 80%. Coarse elements with a diameter of 2 mm also appear at almost the entire depth of the mechanical borehole, except for the first fifteen meters and between 62 and 84 m deep. The percentages of these grains are generally below 10%, except after 80 m, where they reach 70%. Furthermore, no coarse elements are retained by the 3 mm diameter sieve. A single aquifer layer approximately 30 m thick (between 84 and 114 m deep) was therefore identified in this mechanical borehole.

Analysis of Figure 7 relating to the grain size curve of SR03 (SE12) indicates that the 1 mm diameter screen retained coarse elements observed from a depth of 42 m. The proportion of coarse elements with a diameter of 1 mm is significant (>10%) between 60 m and 110 m and from 120 m onwards. The 3 mm diameter screen did not retain anything for this mechanical drilling. These results made it possible to identify the first aquifer between 68 m and 110 m and the second between 122 m and 140 m.

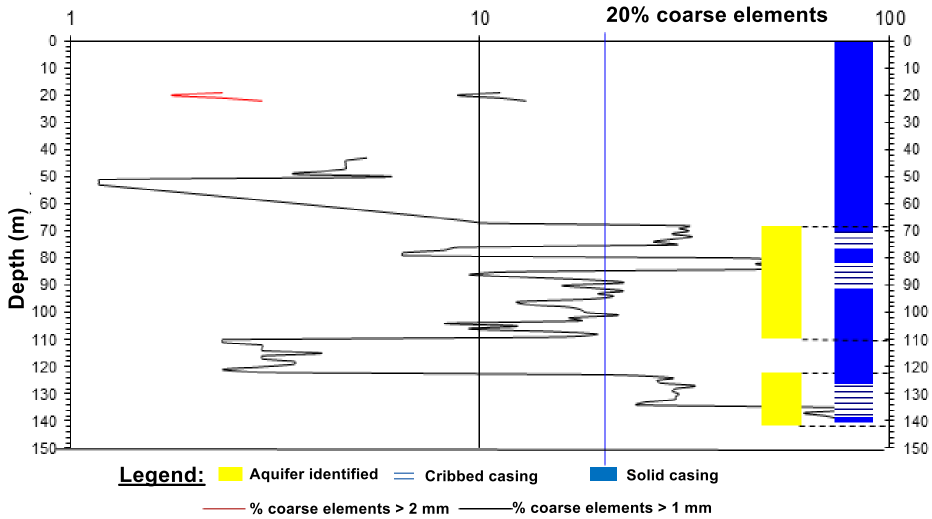

Fig. 7. Grain size curve for reconnaissance drilling SR03 (SE12)

The grain size curve for borehole SR04 (SE03) reveals that there is only one zone where the percentage of coarse elements exceeds 20% (Fig. 8).

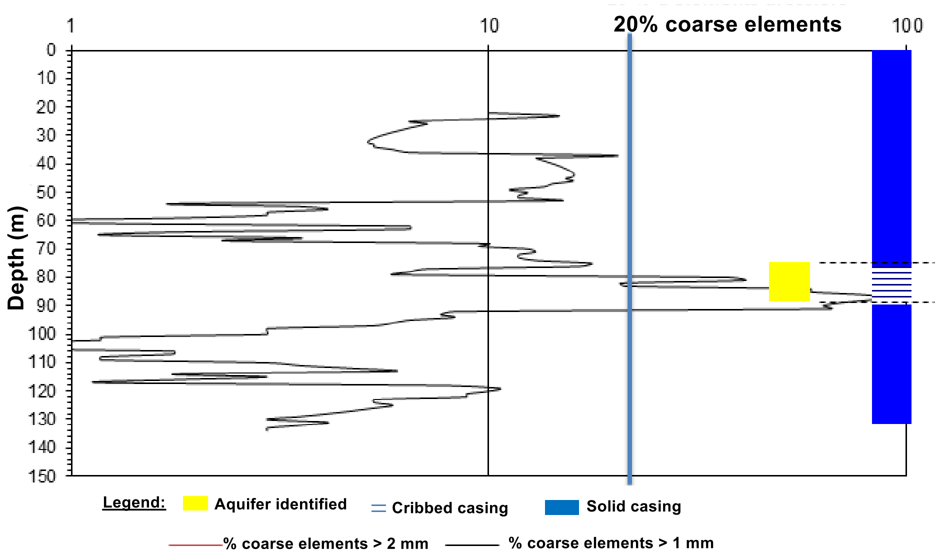

Fig. 8. Grain size curve for reconnaissance borehole SR04 (SE03)

This zone lies between two impermeable layers consisting of very fine particles. The curve representing the percentage of coarse grains with a diameter greater than 2 mm increases from 40 m to 88 m. As for the curve for elements with a diameter of 1 mm, coarse elements were observed from a depth of 40 m to the bottom. The third sieve also retained nothing here.

Borehole SR04 (SE03) therefore identified a single aquifer layer 10 m thick, extending from a depth of 50 m to 60 m. For this layer, the percentages of coarse elements tend towards 100% and fall to less than 10% towards the end of the mechanical borehole.

Table 4 summarizes the results of the grain size curve analyses for the various exploratory boreholes. For each exploratory borehole (drilling), it shows the number of layers constituting the borehole, the aquifer levels identified, and their thicknesses.

Table 4. Results of grain size interpretation

Surveys / Layers	SR01(SE10)		SR02 (SE06)		SR03(SE12)		SR04(SE03)	
	Aquifer identified	Thick. (m)	Aquifer identified	Thick. (m)	Aquifer identified	Thick. (m)	Aquifer identified	Thick. (m)
Layer 1	-	68	-	84	-	61	-	75
Layer 2	+	18	+	30	+	28	+	15
Layer 3	-	12	-	16 and +	-	12	-	40 and +
Layer 4	+	12		-	+	13		
Layer 5	-	4			-	3		
Layer 6	+	14			+	14		
Layer 7	-	6 and +			-	7 and +		

Analysis of the table enabled the four electrical surveys to be classified into two groups. The first group concerned surveys SE10 and SE12. These showed the most stratified terrain, comprising seven layers each, including three aquifers. The second group corresponds to surveys SE06 and SE03. These are less stratified, as these electrical surveys showed three layers each. The latter have only one aquifer zone. Three aquifer layers were identified at depths between 60 m and 114 m. The summary of the survey results and grain size analysis enabled sixteen (16) boreholes to be drilled.

4.3 Characteristics Of Implanted Drillholes

Table 5 below summarizes the characteristics of the sixteen boreholes installed. These include the depth drilled, the depth equipped, and the operating flow rate selected.

Table 5. Characteristics of the boreholes drilled at the selected sites

No. Drilling	Drilled depth (m)	Equipped depth (m)	Operating flow rate Q (m^3/h)
FO 1	164	159	200
FO 2	158.3	155.69	200
FO 3	148	139.4	140
FO 4	162.5	159.88	140
FO 5	152.6	140.79	200
FO 6	130	120	200
FO 7	140.6	134.87	120
FO 8	134.3	130.88	200
FO 9	110.78	110.78	140
FO 10	108	107.76	140
FO 11	109	104.31	250
FO 12	144	142	100
FO 13	132	130.07	100
FO 14	107.5	102.5	100
FO 15	127.5	124.8	250
FO 16	144	138.1	200
Total	-	-	2,680

Table 6 shows operating flow rates ranging from 100 to 250 m^3/h. Eighty-five percent of these boreholes have an operating flow rate greater than or equal to 140 m^3/h. The cumulative flow rate of all boreholes installed in the locality is estimated at 2,680 m^3/h, i.e., a daily flow rate of 64,320,000 l/d or 64,320 m^3/d.

A classification of these operating flow rates (Table 6) showed that all boreholes provided high operating flow rates, with 81.25% of them being very high.

Table 6. Assessment of operating flow rate classes

Flow rate classes (m^3/h)	Number	Percentage (%)	Rating
$100 < Q < 150$	3	18.75	High flow rates
$150 < Q < 200$	5	31.25	Fairly high flow rates
$200 < Q < 250$	8	50	Very high flow rates
Total	16	100	-

5 Discussion

The various surveys (electrical and reconnaissance) indicated that the first aquifers identified from the various electrical surveys have true resistivities greater than 300 Ω.m. This can be explained by the presence of water-saturated sand and gravel. In sedimentary areas, water-saturated sand and gravel are conductive and therefore have low apparent resistivity values [7], [8]. The first layers of aquifers identified are located at depths greater than 60 m. This result is consistent with the work carried out by [9], which estimates that water can be collected at depths greater than 60 m in sedimentary areas. Electrical resistivity in sedimentary soils depends largely on the nature of the interstitial fluid and the matrix [10].

The results of the grain size analyses revealed the grain size of the drilling samples, the aquifer horizons, and their thicknesses. Three aquifers were identified by the SR01 survey. Their percentage of coarse elements (d>1 mm) is greater than 20%. This confirms the presence of coarse elements in these three layers. In addition, these aquifers are separated from each other by layers with fine grain size. These layers were considered useful because they act as impermeable screens protecting against various types of pollution from the soil surface [7].

A single aquifer layer identified by borehole SR02 is characterized by a proportion of coarse elements (d >1 and 2 mm) well above 20%. This layer is also sandwiched between two layers with fine to medium grain size. Finally, the significant thickness (30 m) of this horizon, especially in the Continental Terminal, can guarantee good productivity for the structures that have been built there.

The grain size curve of borehole SR03 showed two aquifer layers. The grain size of these two layers is medium because it was identified by the 1 mm diameter sieve. For the first layer, the percentage of coarse elements tends towards 80% in the levels between 80 and 85 m. In this zone, water can flow easily through the coarse elements (sand and gravel) [11]. According to this author, sand and gravel are highly permeable and allow for the collection of large amounts of water. However, very fine materials (silt and clay) do not easily transmit water and are impermeable. Therefore, the percentage of coarse elements varies between 10 and 20% in the other parts of this first layer. The second layer contains approximately 100% coarse elements and is approximately 20 m thick. In such a configuration, the thickest layer of coarse sand or gravel is likely to provide the highest flow rate [12].

An aquifer layer is determined on the grain size curve of borehole SR04. On this curve, the percentage of grains varies between 10% at around 70 m and 80 m for the 1 mm diameter sieve. This shows that the grain size of this aquifer layer is medium and homogeneous. At a depth of 90 m, the volume of grains obtained increases with the same sieve. However, the grain size becomes quite coarse with the appearance of increasing values for the second sieve with a diameter of 2 mm. This sieve began to retain more coarse elements, hence the increase in grain size. This analysis confirms the results obtained by the lithological section during the mechanical reconnaissance survey.

Coarse elements were encountered before the first sixty meters. These unconfined aquifers were isolated due to their vulnerability to anthropogenic pollution. Indeed, human activities are carried out in the vicinity of the catchment field. The summary grain size analysis carried out made it possible to determine the exact size or diameter of the coarse element samples.

Resistivity is a parameter that is particularly sensitive to moisture, grain size, and porosity. Another technique, electrical logging, provides essential information for characterizing the layers within a large radius around the borehole [13]. To consolidate the grain size results, electrical logging was used to refine the grain size results. High flow rates (100 to 250 m^3/h) were obtained across all structures. These boreholes showed laminar water flow in the aquifers at a uniform velocity.

6 CONCLUSION

After more than fifty years of operation, Benin's drinking water supply infrastructure was no longer able to meet the demands of demographic and urban development. In fact, the water supply had become insufficient. This study therefore aims to establish a field of high-yield boreholes with a view to doubling the water needs of Cotonou and its suburbs by 2015. To achieve this, a combination of geophysics (electrical resistivity and electrical logging) and granulometry was used to locate aquifers likely to contain and drain large quantities of water. The electrical method distinguished the different geological layers that make up the subsoil of the locality. These are characterized by true resistivities ranging from 31.95 to 872.12 Ω, m and true thicknesses ranging from 1.99 to 244.5 m. This method also highlighted the conductive and resistive layers. Four exploratory boreholes were thus drilled. The granulometric analysis of these exploratory boreholes revealed three aquifer layers located at depths between 60 m and 114 m. These aquifers are formed of coarse elements with a diameter greater than 1 mm (fine, medium, and coarse sand and gravel). A collection field of sixteen (16) boreholes was therefore constructed, providing high operating flow rates (between 100 and 250 m^3/h). The cumulative flow rate is estimated at 2,680 m^3/h, or a daily flow rate of 64,320 m^3/day or 64,320,000 l/day.

This supply has met more than 60% of the needs set out in the Millennium Development Goals (MDGs) for drinking water. In fact, in 2015, Benin achieved its drinking water coverage target, reaching a coverage rate of 82% compared to the 75% set by the United Nations.

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