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IMPROVEMENT OF THE DRINKING WATER SUPPLY NETWORK BY STRENGTHENING PRODUCTION USING DRILLING TECHNICS – CASE OF THE MOKALI QUARTER IN THE KIMBANSEKE TOWNSHIP, DR CONGO

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ABSTRACT

Everyone is aware that access to or the search for drinking water is one of the major problems that bother all of humanity. The quarter of MOKALI, in the Kimbanseke township in the Democratic Republic of Congo, also faces challenges in ensuring an adequate supply of drinking water. Current infrastructures, designed several decades ago, are struggling to meet the growing demands of the population. This study focuses on improving the drinking water supply network by strengthening water production through the implementation of advanced drilling technics. Recent studies have highlighted the effectiveness of drilling as a method of accessing deeper aquifers, less prone to contamination and more sustainable over time [1]. In Mokali quarter, the integration of these techniques has not only improved water availability, but also reduced reliance on surface water sources, which are often polluted and unreliable [2],[3]. The use of rotary drilling technology, in particular, has enabled the extraction of high-quality groundwater from depths previously considered inaccessible [3]. The implementation of these technics was coupled with the modernization of the water distribution network, ensuring that the increase in production capacity directly translates into better access for the local population [3],[4]. The results of this study indicate a significant reduction in water shortage incidents and an overall improvement in public health outcomes in Mokali quarter. The success of this project suggests that similar strategies could be applied effectively in other regions facing comparable challenge.

Keywords: water supply network, drilling technics, deeper aquifers, Mokali district, Kimbanseke, groundwater

INTRODUCTION

The harmonious development of any economy has always and everywhere been subordinated to the control of water. Access to drinking water is an important issue in the world. All humanity continues to need drinking water in sufficient quantity and quality for a multitude of tasks, and the quality of this water influences the health of the population [2]. Like many African metropolises, the city of Kinshasa is facing exponential population growth and consequently the need for water is great. Unfortunately, this growth is not always followed by the development of certain basic infrastructures to promote economic and social growth in order to ensure the well-being of the population.

In the latter, water distribution is ensured by REGIDESO which today is experiencing enormous difficulties which prevent this service from distributing drinking water in sufficient quantity and quality, thereby leading to the absence of water. total or partial within the population [18]. This disruption in water distribution results in several phenomena, namely: insufficient pressure in the neighborhood, insufficient overall resource which can lead to a cessation of distribution during peak hours, aging of the pipes, etc. We may have a sufficient overall resource but it is poorly distributed during the peak day, thus causing a shutdown of distribution for part of that day [2],[7].

However, the Mokali quarter, one of the quarters of the Kimbanseke township, is not immune to these types of phenomena. It faces a problem of insufficient overall resources which could lead to a stoppage of distribution during the peak day.

The main objective of the study is to improve the conditions of drinking water supply in the Mokali quarter, proposing optimization measures and evaluating the drinking water needs by 2049 by ensuring regular availability of this resource so that consumers benefit from it with sufficient pressure at the tap.

Groundwater seems advantageous to us to meet the drinking water needs of the population of the Mokali quarter, because of its low operating cost compared to that of surface water. The exploitation of this water will be done by means of drilling and we will deduce the number [3],[8]. To do this, we first had to gather the necessary data before any distribution of drinking water, among other things: demographic, hydrological and socio-economic data. Consequently, we assessed the water needs of the Mokali quarter to finally deduce the daily water production capacity, year by year until 2049.

Knowing that our country the DRC has abundant underground water resources, we as engineers want to take advantage of this opportunity to find a lasting solution to this thorny problem by means of drilling.

METHODOLOGICAL APPROACH

Presentation of the site

The Mokali quarter is one of the districts of the commune of Kimbanseke. It was created on April 28, 1981 by the decision of the municipal authority whose headquarters of the institution is on avenue YASSA 01 bis. It is a cell of the commune of Kimbanseke, not having been given legal personality. Any act of a criminal nature is immediately referred to the municipality, except in the event of an emergency to the sub-ciat having general jurisdiction in the matter [8].

As illustrated in Figure 1, Mokali sector network is supplied by the DN 350 AJA (Acier Juté Asphalté), connected to the DN 700 coming from the N'djili factory along the boulevard to the N'djili Airport. Furthermore, the network is reinforced by the DN 800 cast iron coming from the N’djili factory. Although the network benefited from the reinforcement of the DN 800 in cast iron, the northern part of the district suffers from a partial and total lack of water linked to insufficient production. The cast iron DN 800 reinforced the DN 350 passing through the streets: Masuekama, Mangele, Nzungu and Dibaya beyond the Mokali bridge. A small part is supplied by a borehole, starting from Ngaliema street, Dispensary and part of Malonda.

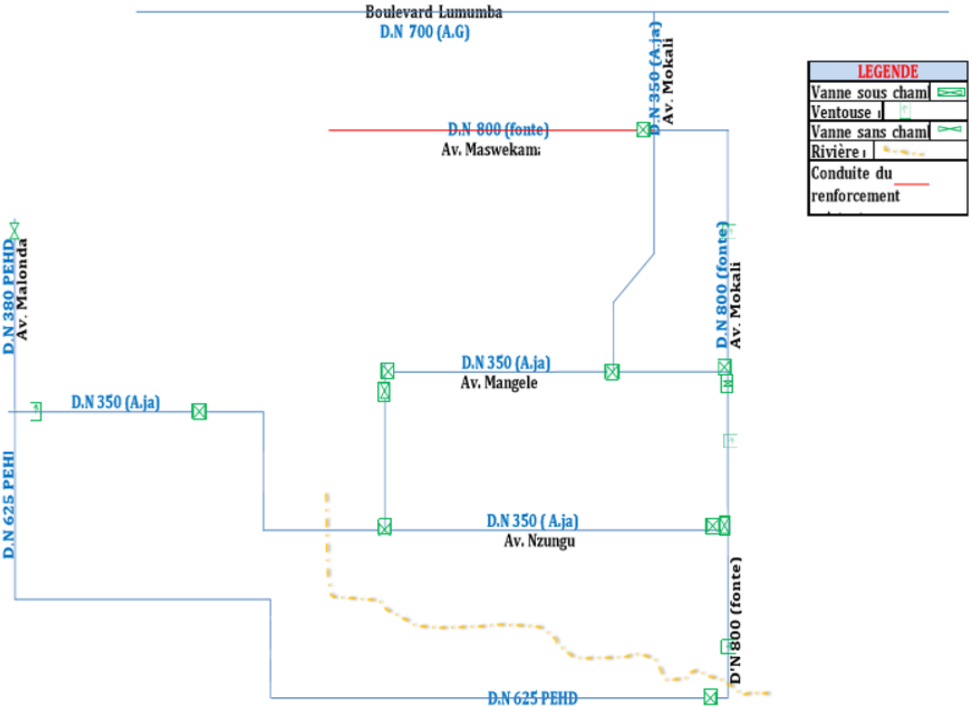

Figure 1. *Existing network of the Mokali quarter* [10]

METHODS

The development of this work leads us to use the following methods:

Documentary method

We collected information from books, various written documents such as articles and posts on Websites. This allowed us to deepen our understanding about the history of the Mokali district, the existing hydraulic network and the description of its various facts.

Data collect and analysis

The interview by contacting some officials of public institutions such as the Kimbanseke communal house, the Mokali quarter office and Regideso for details on the population of the area and the characteristics of the existing drilling. Then, a field visit was carried out identify the machines and devices likely used for this drilling. Once these machines were identified, the operating characteristics were also collected.

Comparative method

It made it easier to examine and compare the evolution of the indicators obtained from one year to the next to extend our study until 2049 and to draw conclusions about the subject of our research based on general considerations.

Drill sizing method

Sizing a borehole is a crucial step in the design of groundwater capture systems. It involved several steps to ensure that the drilling met the needs in terms of flow and water quality while being sustainable and efficient. We understood the geology of the site, the types of rocks present, and the depth of potential aquifers. After assessing water needs, we had determined the number and drilling Parameters such as the operating flow rate (Q_{max}), the diameter (D) and the depth of the drilling (H). We then made the technical designs while also determining the choice of the electropump group.

Method of sizing the distribution network and storage system (tank)

Knowing the necessary need, we proceeded to determine the volume of the tank and that of the cover. Thanks to EPANET, we designed a complete network by determining the pressure in each section and the pressure losses, planning the locations of all fourteen 14 boreholes in order to allow the population to avoid traveling long distances.

RESULTS AND ANALYSYS

Data collect and evolution of the population

There is a borehole on the Mokali site belonging to Regideso, which serves part of the said quarter. The latter, characterized by insufficient production, does not meet the real needs of the population. It works thanks to a submerged pump powered by a 30 kVa generator, from where the tank is filled by pumping. Its characteristics are shown in table 1 below.

Table 1. *Drilling characteristics*

Depth of the tablecloth	105 m
Height of the castle	25 m
Tank capacity	50 m^3
Submersible pump	10 m^3/h (for 4 hours of operation)

Domestic population

Already knowing the growth rate, we can determine the population for the year 2024:

$$P_{2024} = P_{2023}(1 + 0.035)^n \quad (1)$$

For n=1, P_{2024}=31845(1+0.035) = 32960 residents (2)

The future population is a population which the designer determines for a given period. This period depends on the evaluation of the population and the planned works, the lifespan of the materials to be used. The projection of the future population as part of our study extends over a period of 25 years.

$$P_n = P_0(1 + r)^n \quad (3)$$

for n = 25,

$$P_{2049} = P_{2024}(1 + 0.035)^{25} \quad (4)$$

$$P_{2049} = 77893 \text{ residents} \quad (5)$$

Public facilities

By considering an increase of 20%, or 0.20 for all current workforce, we obtain the future workforce, as shown in table 2.

Table 2*. Populations in Public Facilities*

N^0	***Wording***	***Current workforce***	***Future workforce (2049)***
1	*Schools*	4290 students	5148 students
2	*Churches*	23 assembly	28 assembly
3	*Medical centers*	114 beds	137 beds
4	*Hotels*	42 beds	51 beds
5	*Administration*	26 agents	31 agents
6	*Markets*	700 m^2	840 m^2

Evaluation of the specific consumption

We call characteristic consumption (CC) the consumption of all users including the fire reserve. There are two types of water losses including apparent water losses due to the meter and real water losses caused by water leaks and fraudulent connection into the network [23],[29].

Overall, these losses (apparent or real) are estimated at 20% of total consumption [30] and are often high for municipalities with very old or dilapidated distribution networks and leaks. Water losses = CC * 0.20

Thus, we obtain the current characteristic consumptions as shown in table 3.

Table 3. *Summary of current daily consumption*

Nº	***Designations***	***Current population***	***Current endowment***	***Current consumption in l/j***
1	*Domestics*	32960	50 l/res/day	1648000
2	*Schools*	4290	10 l/stud/day	42900
3	*Churches*	23	100 l/ass/day	2300
4	*Medical centers*	114	250 l/bed/day	28500
5	*Hotels*	42	200 l/bed/day	8400
6	*Administrations*	26	40 l/ag/day	1040
7	*Markets*	700	5 l/m²/day	3500
8	*Fire reserve*		2 hours	96
9	*Water loss*	20%xCC		346947
10	***Total***			**2081683**

In the same way, we determine the future characteristic consumptions as shown in table 4.

Table 4. *Summary of current daily consumption*

Nº	***Designations***	***Current population***	***Current endowment***	***Current consumption in l/j***
1	*Domestics*	77893	60 l/res/day	4673580
2	*Schools*	5148	12 l/stud/day	61776
3	*Churches*	28	120 l/ass/day	3360
4	*Medical centers*	137	300 l/bed/day	41100
5	*Hotels*	51	240 l/bed/day	12240
6	*Administrations*	31	48 l/ag/day	1488
7	*Markets*	840	6 l/m²/day	5040
8	*Fire reserve*		2 hours	96
9	*Water loss*	20%xCC		959736
10	***Total***			**5758416**

Flow calculations

For network design, estimating needs requires knowing the average daily flow, the daily peak flow and the hourly point flow. Remember that water consumption is not constant, it varies according to the months of the year, the weeks of the month, the days of the week and the hours of the day. For this reason, it is necessary to design equipment that can adequately satisfy this various maximum as well as minimum consumption [4].

- The current average daily flow will be determined by taking the ratio of the current total daily consumption to the number of seconds in a day
- Goodrich's empirical formula predicts peak consumption of various durations for small residential municipalities. The values of t (time in seconds) can vary from $2/24 < t < 366$ days:

$$P = 180\, t^{-0.10} \tag{6}$$

which allows us to determine the current peak flow rates as shown in the table 5.

Table 5. *Current peak flow 2024*

Peak flow	***Current average flow in l/s***	***Coefficient de pointe***	***Current peak flow in l/s***
Monthly peak flow	24	1.28	30.72
Weekly peak flow	24	1.48	35.52
Daily peak flow	24	1.8	43.2
Hourly peak flow	24	2.3	55.2
Min peak flow	24	0.5	12

In the same way, we determine the future peak flow rates as shown in the table 6.

Table 6. *Future peak flow 2049*

Peak flow	***Future average flow in l/s***	***Coefficient de pointe***	***Future peak flow in l/s***
Monthly peak flow	66.65	1.28	85.31
Weekly peak flow	66.65	1.48	98.64
Daily peak flow	66.65	1.8	119.97
Hourly peak flow	66.65	2.3	153.30
Min peak flow	66.65	0.5	33.325

Moreover,

- maximum flow will be evaluated by the product of the future average flow and the peak coefficient.
- The minimum peak flow is the product of the current average flow by the minority coefficient which varies from 40 to 50% (0.4 to 0.5) often between 3 to 4 a.m. In our project, we consider 0.5 which allows us to determine the current peak flow rates as shown in the table 7.

Table 7. *Summary of current and future daily flow rates*

N°	*Désignations*	*Current (2024) l/s*	*Future (2049) l/s*
1	*Maximum flow*	*43.2*	*119.97*
2	*Minimum flow*	*12*	*33.33*

Source of supply

The waters of the Mokali rivers in the Mokali quarter were not retained because of their low flow; they dry up during the dry season. Groundwater remains the only credible source of supply given the abundance of water in the aquifer through its hydrographic network, its rainfall and its marshland.

Drilling number calculations [3]

The number of drilling is the ratio between the project flow and the operating flow:

$$N = \frac{Q_p}{Q_e} \tag{7}$$

N: number of drillings

Q_e: operating flow (the flow not to be exceeded in a site)

On our site the operating flow rate does not exceed 30 m^3/h according to information obtained from the ONHR in charge of rural hydraulics.

Q_p: the flow rate of the project.

For our study, our project flow rate was calculated in the previous chapter, which is 119.97 l/s (according table 7).

The number of drillings is calculated as follows:

$$\frac{Q_{max}}{Q_{exp}} = \frac{431.89 m^3/h}{30\ m^3/h} = 14\ drilling\ wells \tag{8}$$

Distance between two boreholes

The distance between two boreholes is given by:

$$D = 2R \tag{9}$$

with:

D = distance between two boreholes,

R = radius of influence

$$Radius = 1000.\ (H\text{-}h)\ \sqrt{k} \tag{10}$$

K: Permeability coefficient, which depends on the type of soil

The soil type for our study area is sandstone.

R = 1000. (30-22) √0.0001 = 80 m

Therefore, *the distance between two drilling wells will be 160 meters.*

Choice of the Pump

For the calculation of the pump and the choice thereof, we find the following elements: the flow rate, the head, the absorbed power, the efficiency possibly and the specific speed [3],[6].

- ✓ Manometric Head

$$HMT = Hg + \sum h\Delta h \tag{11}$$

$Hg = (Hr\text{-}Ha)$ + drilling depth, with

Hr: discharge height

Ha: suction height

Hg= (365-320) +105 ⟶ Hg = 150 m

after calculation and using the Colebrook charts, we have:

$$HMT = 152.608 \text{ m} \tag{12}$$

We used the abacus diagram to choose our pump knowing that our head is 152.608 m and the Q_{max} is 119.97 l/s. We can adopt the model Grundfos CR 255-3.

$$\eta_{pump} = \frac{Phyd}{Pmec} \tag{13}$$

with: η_{pump}: pump performance

P_{hyd}: hydraulic power

P_{mec}: mechanic power

Since the motor activates the pump, its efficiency is worth:

$$\eta = \frac{Pméc}{Pélec} \tag{14}$$

For (13): $P_{méc} = Pv = \frac{Phyd}{\eta pump} = \frac{\varphi * Q * H * g}{\eta pump} \quad \rightarrow \quad P_{méc} = \frac{Phyd}{\eta pump}$ (15)

P_{hyd} = 1000 kg/m^3 * 9.81 m/s² * 153m * 0.19997 m^3/s = 180066.57 Watts

Consider, $\eta_{pump} = 0.75$

$$P_{méc} = \frac{180.067}{0.75} \text{ Kw} \rightarrow \text{P}_{\text{méc}} = 240 \text{ KW} \tag{16}$$

The mechanical power is the nominal power shown on the motor nameplate.

Dimensions of the distribution network and storage system (tank)

Conveyance is the transfer of water from the natural source or treatment plant to the distribution reservoir.

In our project, this pipe has the role of transporting the water from the well to the tank and we will call the discharge pipe that which will leave the tank to the storage or distribution tank [31].

The supply to our site will be combined, that is to say from the wells to the tank and from the tank to the storage tank (distribution) by pressure pipe and from the tank to consumers by gravity.

Dimension of the supply pipe

Based on our study we have 14 boreholes of 30 m^3/h as operating flow, on this the total flow which will convey in the water supply pipe is:

$$Q_t = 14 \times 30 = 420\ m^3/h = \frac{420}{3600}\ m^3/s = 0.117\ m^3/s$$

Hence:

$$D = \sqrt{Q} = \sqrt{0.117} = 0.342\ m = 342\ mm \tag{17}$$

Either:

$$D = 350\ mm \text{ (Commercial Diameter)}$$

$$V = \frac{4Q}{\pi D^2} = \frac{4(0.117)}{3.14(0.350)^2} = \frac{0.468}{0.38465} = 1.20\ m/s \tag{18}$$

Actual dimension of the air reservoir and pressure

Knowing that:

L= 900 m; D = 0.35 m; Q=0.117m^3/s; V_o=1.2 m/s; e =1 cm and H_o=80 m

Which allows us after several calculations to obtain the results shown in the table 8.

Table 8. *Dimension of the air reservoir and pressure*

N°	***Désignations***	***Values***
1	*reservoir volume*	*43.2 m^3*
2	*minimum pressure*	*30.5 m*

Dimensions of the Tarpaulin

The Table 9 help use to determine the volume of the Tarpaulin

Table 9. *Dimensions of the Tarpaulin*

Hours	***Incoming Volume in m^3/h***	***Cumulative Incoming Volume in m3/h***	***Ongoing Volume in m^3/h***	***Cumulative Ongoing Volume in m^3/h***	***Col3 - Col5***
0 – 1	431.89	431.89	0	0	431.89
1 – 2	431.89	863.78	0	0	863.78
2 – 3	431.89	1295.67	518.27	518.27	777.4
3 – 4	431.89	1727.56	518.27	1036.54	691.02
4 – 5	431.89	2159.45	518.27	1554.81	604.64

5 – 6	431.89	2591.34	518.27	2073.08	518.26
6 – 7	431.89	3023.23	518.27	2591.35	431.88
7 – 8	431.89	3455.12	518.27	3109.62	345.5
8 – 9	431.89	3887.01	518.27	3627.89	259.12
9 – 10	431.89	4318.9	518.27	4146.16	172.74
10 – 11	431.89	4750.79	518.27	4664.43	86.36
11 – 12	431.89	5182.68	518.27	5182.7	0
12 – 13	431.89	5614.57	518.27	5700.97	-86.4
13 – 14	431.89	6046.46	518.27	6219.24	-174.78
14 – 15	431.89	6478.35	518.27	6737.51	-259.16
15 – 16	431.89	6910.24	518.27	7255.78	-345.54
16 – 17	431.89	7342.13	518.27	7774.05	-431.92
17 – 18	431.89	7774.02	518.27	8292.32	-518.3
18 – 19	431.89	8205.91	518.27	8810.59	-604.68
19 – 20	431.89	8637.8	518.27	9328.86	-691.06
20 – 21	431.89	9069.69	518.27	9847.13	-777.44
21 – 22	431.89	9501.58	518.27	10365.4	-863.82
22 – 23	431.89	9933.47	0	10365.4	-431.93
23 – 24	431.89	10365.36	0	10365.4	0

- ✓ It appears that the concentration or pumping time = 20 hours
- ✓ Tarpaulin volume = largest positive value + largest negative value

  Tarpaulin volume = 863.78+863.82 =1728 m^3 (19)

Dimension of the reservoir

To do this, we adapt the consumption curve method. The calculations allow us to arrive at the following table 10.

Table 10. *Value for tank sizing*

Hours	***Production***	***Hourly peak coefficient***	***Volume of water consumed***	***Remaining water volume***	***Cumulative water volume***
	A	B	C= A x B	D=A-C	
0-1	431.89	0.3	129.57	302.32	302.32
1-2	431.89	0.3	129.57	302.32	604.64
2-3	431.89	0.3	129.57	302.32	906.97
3-4	431.89	0.3	129.57	302.32	1209.29
4-5	431.89	0.3	129.57	302.32	1511.61
5-6	431.89	1.8	777.40	-345.51	1166.10
6-7	431.89	1.8	777.40	-345.51	820.59

7-8	431.89	1.5	647.84	-215.95	604.64
8-9	431.89	1.5	647.84	-215.95	388.70
10-11	431.89	1.5	647.84	-215.95	172.75
11-12	431.89	1.5	647.84	-215.95	-43.19
12-13	431.89	1.2	518.27	-86.38	-129.57
13-14	431.89	1.2	518.27	-86.38	-215.95
14-15	431.89	1	431.89	0.00	-215.95
15-16	431.89	1	431.89	0.00	-215.95
16-17	431.89	1.4	604.65	-172.76	-388.70
17-18	431.89	1.4	604.65	-172.76	-561.46
18-19	431.89	1.4	604.65	-172.76	-734.22
19-20	431.89	0.9	388.70	43.19	-691.03
20-21	431.89	0.9	388.70	43.19	-647.84
21-22	431.89	0.9	388.70	43.19	-604.65
22-23	431.89	0.7	302.32	129.57	-475.08
23-24	431.89	0.6	259.13	172.76	-302.33

Thus,

Cumulative water volume = 1166.10 + 734.22 = 1900 m^3 (20)

Since our volume is greater than 1000 m^3, we opt for 5 m of water height.

So, $V = S \times h \Rightarrow S = \frac{V}{h} \Leftrightarrow \frac{1900}{5} = 380$ m^2

And, the diameter, D = $\sqrt{4 \text{ x } 380/3.14}$ = 22 m

Tank height = $H_e + H_r + H_m$

With H_e: water height in m, i.e. 5 m

H_r: height of the air draft, i.e. 10% of the water height

H_m: maintenance height, i.e. 0.25m

Tank Volume = Surface x Tank height = 380 x 5.75 = 2185 m^3 (21)

Finally, the volume of the tank is 2185 m^3.

Distribution system

In the case of the Mokali quarter, we adopted a system with pumping and storage then distribution by gravity to the extent that the topography of the land offers interesting differences in level. For the drinking water distribution network, we dimension three (3) important parameters which are as follows: Flow rates, Speeds and Pressures. The Table 7 shows the values of speed, rate of flow and load losses in each section

Table 11. *Pipe characteristics*

N°	Section	Length (m)	Rate of flow		Dmin (mm)	Dmax (mm)	DN (mm)	V (m/s)	Load losses ΔH (m)
			Q (l/s)	Q (m^3/s)					
1	R-1	30	153.3	0.15330	360.8	625.0	400	1.221	0.0877
2	1--2	96	17.52	0.01752	122.0	211.3	125	1.428	1.5813
3	2--BF1	5	4.38	0.00438	61.0	105.6	80	0.872	0.0506
4	2--3	144	13.14	0.01314	105.6	183.0	125	1.071	1.3342
5	3--BF2	7	4.38	0.00438	61.0	105.6	80	0.872	0.0708
6	3--4	180	8.76	0.00876	86.3	149.4	100	1.116	2.2621
7	4--BF3	6	4.38	0.00438	61.0	105.6	80	0.872	0.0607
8	4--5	168	4.38	0.00438	61.0	105.6	80	0.872	1.7003
9	5--BF4	7	4.38	0.00438	61.0	105.6	80	0.872	0.0671
10	1--6	72	21.9	0.02190	136.4	236.2	150	1.240	0.7033
11	6--BF5	6	4.38	0.00438	61.0	105.6	80	0.872	0.0607
12	6--7	120	17.52	0.01752	122.0	211.3	150	0.992	0.7502
13	7--BF6	5	4.38	0.00438	61.0	105.6	80	0.872	0.0506
14	7--8	102	13.14	0.01314	105.6	183.0	125	1.071	0.9451
15	8--BF7	8	4.38	0.00438	61.0	105.6	80	0.872	0.0810
16	8--9	126	8.76	0.00876	86.3	149.4	100	1.116	1.5835
17	9--10	156	4.38	0.00438	61.0	105.6	80	0.872	1.5788
18	10--BF8	9	4.38	0.00438	61.0	105.6	80	0.872	0.0911
19	9--11	78	4.38	0.00438	61.0	105.6	80	0.872	0.7894
20	11--BF9	8	4.38	0.00438	61.0	105.6	80	0.872	0.0810
21	1--12	216	113.88	0.11388	311.0	538.6	350	1.184	0.7279
22	12--13	60	35.04	0.03504	172.5	298.8	200	1.116	3.3512
23	13--BF10	7	4.38	0.00438	61.0	105.6	80	0.872	0.0708
24	13--14	102	30.66	0.03066	161.4	279.5	200	0.976	4.3618
25	14--BF11	9	4.38	0.00438	61.0	105.6	80	0.872	0.0911
26	14--15	108	26.28	0.02628	149.4	258.8	150	1.488	1.5192
27	15--BF12	8	4.38	0.00438	61.0	105.6	80	0.872	0.0810
28	15--16	90	21.9	0.02190	136.4	236.2	150	1.240	0.8792
29	16--BF13	8	4.38	0.00438	61.0	105.6	80	0.872	0.0810
30	16--17	96	17.52	0.01752	122.0	211.3	150	0.992	0.6002
31	17--BF14	7	4.38	0.00438	61.0	105.6	80	0.872	0.0708
32	17--18	96	13.14	0.01314	105.6	183.0	125	1.071	0.8895
33	18--BF15	9	4.38	0.00438	61.0	105.6	80	0.872	0.0911

34	18--19	90	8.76	0.00876	86.3	149.4	100	1.116	1.1310
35	19--BF16	6	4.38	0.00438	61.0	105.6	80	0.872	0.0607
36	19--20	186	4.38	0.00438	61.0	105.6	80	0.872	1.8824
37	20--BF17	8	4.38	0.00438	61.0	105.6	80	0.872	0.0810
38	12--21	312	78.84	0.07884	258.8	448.2	300	1.116	1.0891
39	21--22	60	39.42	0.03942	183.0	316.9	200	1.255	4.2414
40	22--BF18	9	4.38	0.00438	61.0	105.6	80	0.872	0.0911
41	22--23	150	35.04	0.03504	172.5	298.8	200	1.116	8.3781
42	23--BF19	8	4.38	0.00438	61.0	105.6	80	0.872	0.0810
43	23--24	150	30.66	0.03066	161.4	279.5	200	0.976	6.4145
44	24--BF20	7	4.38	0.00438	61.0	105.6	80	0.872	0.0708
45	24--25	132	26.28	0.02628	149.4	258.8	150	1.488	1.8568
46	25--BF21	9	4.38	0.00438	61.0	105.6	80	0.872	0.0911
47	25--26	126	21.9	0.02190	136.4	236.2	150	1.240	1.2309
48	26--BF22	8	4.38	0.00438	61.0	105.6	80	0.872	0.0810
49	26--27	96	17.52	0.01752	122.0	211.3	125	1.428	1.5813
50	27--BF23	7	4.38	0.00438	61.0	105.6	80	0.872	0.0708
51	27--28	138	13.14	0.01314	105.6	183.0	125	1.071	1.2786
52	28--BF24	6	4.38	0.00438	61.0	105.6	80	0.872	0.0607
53	28--29	192	8.76	0.00876	86.3	149.4	100	1.116	2.4129
54	29--BF25	8	4.38	0.00438	61.0	105.6	80	0.872	0.0810
55	29--30	90	4.38	0.00438	61.0	105.6	80	0.872	0.9109
56	30--BF26	6	4.38	0.00438	61.0	105.6	80	0.872	0.0607
57	21--31	246	39.42	0.03942	183.0	316.9	200	1.255	17.3897
58	31--41	138	4.38	0.00438	61.0	105.6	80	0.872	1.3966
59	41--BF27	6	4.38	0.00438	61.0	105.6	80	0.872	0.0607
60	31--32	48	35.04	0.03504	172.5	298.8	200	1.116	2.6810
61	32--BF28	5	4.38	0.00438	61.0	105.6	80	0.872	0.0506
62	32--33	150	30.66	0.03066	161.4	279.5	200	0.976	6.4145
63	33--BF29	7	4.38	0.00438	61.0	105.6	80	0.872	0.0708
64	33--34	204	26.28	0.02628	149.4	258.8	150	1.488	2.8696
65	34--35	180	4.38	0.00438	61.0	105.6	80	0.872	1.8217
66	35--BF30	8	4.38	0.00438	61.0	105.6	80	0.872	0.0810
67	34--36	48	21.9	0.02190	136.4	236.2	150	1.240	0.4689
68	36--BF31	6	4.38	0.00438	61.0	105.6	80	0.872	0.0607
69	36--37	108	17.52	0.01752	122.0	211.3	125	1.428	1.7790

70	37--BF32	8	4.38	0.00438	61.0	105.6	80	0.872	0.0810
71	37--38	96	13.14	0.01314	105.6	183.0	125	1.071	0.8895
72	38--BF33	9	4.38	0.00438	61.0	105.6	80	0.872	0.0911
73	38--39	174	8.76	0.00876	86.3	149.4	100	1.116	2.1867
74	39--BF34	7	4.38	0.00438	61.0	105.6	80	0.872	0.0708
75	39--40	324	4.38	0.00438	61.0	105.6	80	0.872	3.2791
76	40--BF35	10	4.38	0.00438	61.0	105.6	80	0.872	0.1012

It appears from this table that the total length of the pipes is 16986 m. There are 35 standpipes allowing water to be distributed comfortably for use and ensuring good hygiene of distribution with a flow rate of 4.38l/s. For each fountain, we have two types of faucets: 5 faucets of $\frac{1}{2}$ inch and 1 faucet of $\frac{3}{4}$ inch. Moreover, the Table 12 shows the values of hydraulic pressures and loads.

Table 12*. Values of hydraulic pressures and loads.*

N°	***Knots***	***Altitudes (m)***	***Pressures (m)***	***Pressures (bar)***	***Hydraulic Loads (m)***
1	1	359	6.91	0.7	365.91
2	2	345	19.27	1.9	364.27
3	3	334	28.85	2.8	362.85
4	BF1	349	15.21	1.5	364.21
5	BF2	341	21.27	2.1	362.27
6	4	335	25.32	2.5	360.32
7	BF3	337	23.25	2.3	360.25
8	5	323	35.37	3.4	358.37
9	BF4	320	38.29	3.7	358.29
10	6	354	11.16	1.1	365.16
11	7	340	24.35	2.4	364.35
12	8	328	35.34	3.4	363.34
13	9	326	35.57	3.4	361.57
14	10	324	35.76	3.5	359.76
15	11	325	35.67	3.5	360.67
16	BF5	355	10.09	1.0	365.09
17	BF6	339	25.29	2.4	364.29
18	BF7	327	36.25	3.5	363.25
19	BF8	322	37.66	3.6	359.66
20	BF9	325	35.58	3.4	360.58
21	12	360	5.18	0.5	365.18
22	13	355	9.82	1.0	364.82
23	BF10	354	10.74	1.0	364.74

24	14	347	17.35	1.7	364.35
25	BF11	346	18.25	1.8	364.25
26	15	340	22.76	2.2	362.76
27	BF12	341	21.67	2.1	362.67
28	16	334	27.83	2.7	361.83
29	BF13	335	26.73	2.6	361.73
30	17	329	32.18	3.1	361.18
31	BF14	328	33.09	3.2	361.09
32	18	326	34.23	3.3	360.23
33	BF15	326	34.13	3.3	360.13
34	19	325	33.97	3.3	358.97
35	BF16	325	33.9	3.3	358.9
36	20	323	33.81	3.3	356.81
37	BF17	322	34.71	3.4	356.71
38	21	350	14.05	1.4	364.05
39	22	349	14.6	1.4	363.6
40	BF18	350	13.5	1.3	363.5
41	23	346	16.17	1.6	362.17
42	BF19	346	16.62	1.6	362.62
43	24	336	26.02	2.5	362.02
44	BF20	335	26.94	2.6	361.94
45	25	330	30.07	2.9	360.07
46	BF21	329	30.97	3.0	359.97
47	26	327	31.76	3.1	358.76
48	BF22	327	31.67	3.1	358.67
49	27	324	33.12	3.2	357.12
50	BF23	324	33.04	3.2	357.04
51	28	319	36.76	3.6	355.76
52	BF24	319	36.69	3.6	355.69
53	29	318	35.07	3.4	353.07
54	BF25	320	32.97	3.2	352.97
55	31	345	17.21	1.7	362.21
56	41	335	26.61	2.6	361.61
57	BF27	332	28.54	2.8	360.54
58	32	340	21.93	2.1	361.93
59	BF29	341	20.87	2.0	361.87
60	33	338	23.24	2.2	361.24
61	BF29	339	22.16	2.1	361.16
62	34	334	24.23	2.3	358.23
63	35	325	31.14	3.0	356.14

64	30	325	31.05	3.0	356.05
65	36	331	26.73	2.6	357.73
66	BF31	331	26.66	2.6	357.66
67	37	327	28.89	2.8	355.89
68	BF32	325	30.79	3.0	355.79
69	38	323	31.94	3.1	354.94
70	BF33	321	33.84	3.3	354.84
71	39	321	31.5	3.0	352.5
72	BF34	321	31.42	3.0	352.42
73	40	319	29.73	2.9	348.73
74	BF35	320	28.62	2.8	348.62
75	30	317	35.02	3.4	352.02
76	BF26	315	36.95	3.6	351.95

Network simulation using Epanet software

EPANET is software developed for simulating the behavior of water distribution systems from a hydraulic point of view and also from a water quality point of view. The network simulation result give us the presentation of the network, the characteristic curve of the pump and the longitudinal profile respectively as illustrated in the figures 2, 3 and 4. We see that there are 35 standpipes allowing water to be distributed comfortably for use and ensuring good hygiene of distribution.

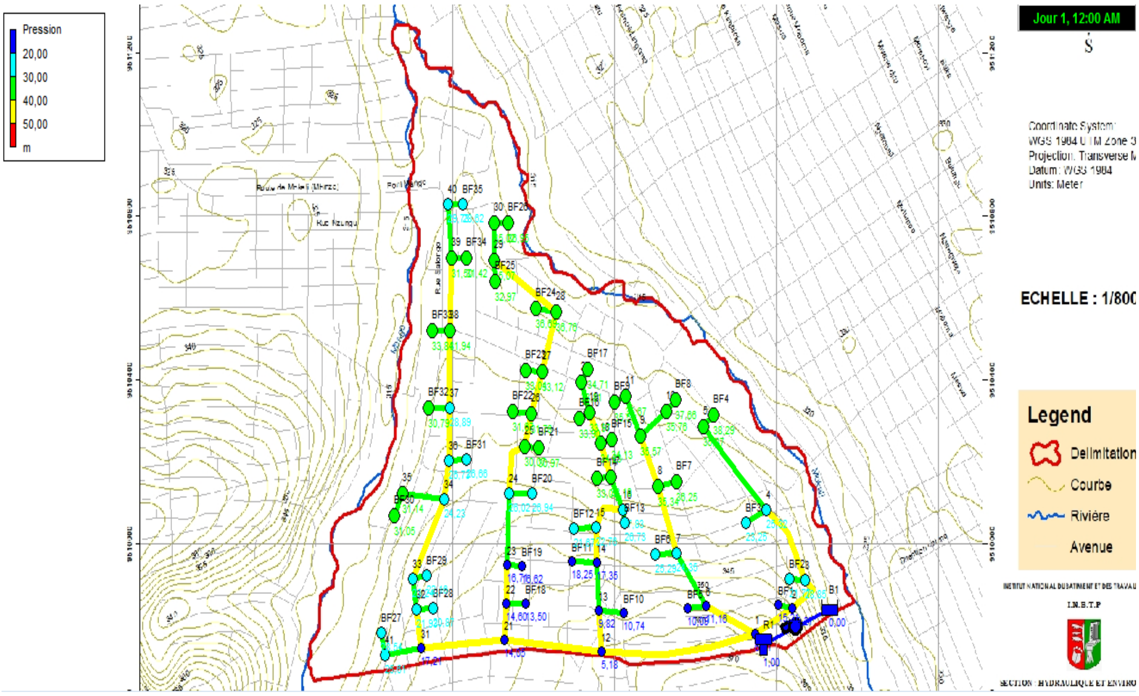

Figure 2*. Presentation of the hydraulic network*

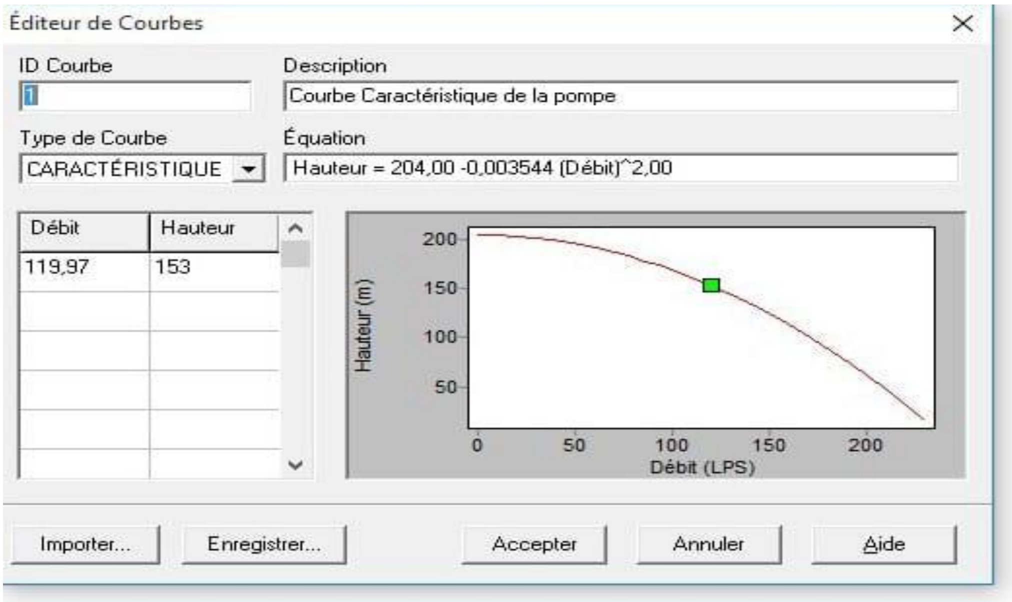

Figure 3. *Pump characteristic curve*

This curve is because at low flow rates the pump can generate higher pressure, but at higher flow rates the pressure decreases because the pump must move a greater volume of fluid.

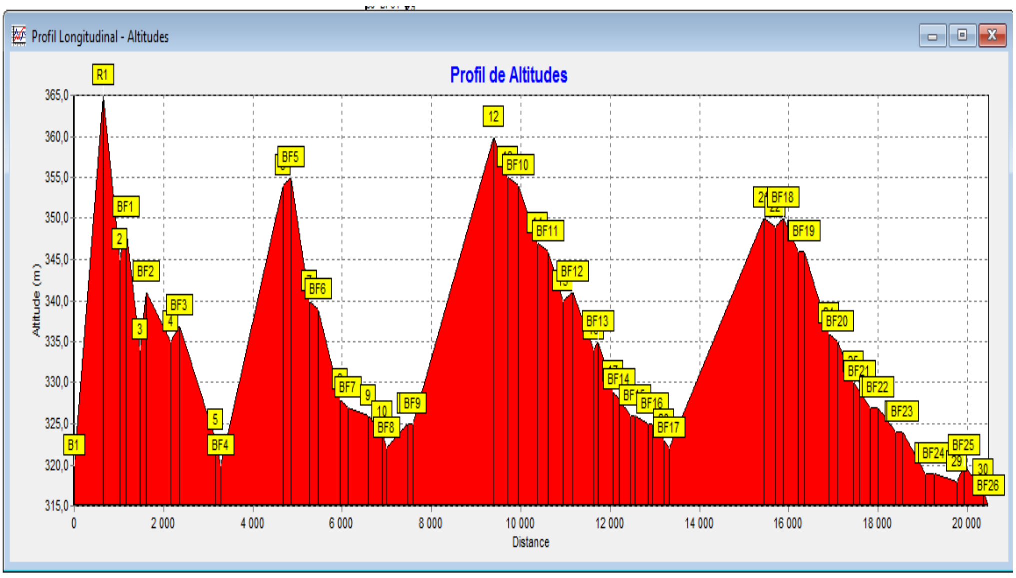

Figure 4. *Longitudinal profile of the system*

This altitude profile shows the variation in land elevation between the points where drilling is planned. These values are between 317 and 365 meters. graphic allows us to observe the slopes, high points, valleys, and plateaus along the route and to optimize our system in the case of future studies.

Investment estimate

Table 13 shows us the financial estimate for carrying out this study

Num.	Désignations	Ute	Qty	U.P(€)	T.P(€)
1	Installation of the construction site				
1,1	Installation and withdrawal of the site	FF	14	2500	35000
1,2	Technician Services	Person.	12		
	Subtotal 1				35000
2	Supply and Consumables				
2,1	Protection tube in steel or PVC DN 350 mm	M	560	180	100800
2,2	Blind Threaded PVC Pipe DN 140 PN 16 (L=3 m)	Pce	434	130	56420
2,3	Threaded PVC Strainer Pipe DN 140 PN 16 (L=3m)	Pce	196	140	27440
2,4	Threaded PVC Bottom Plug DN 140PN 16	Pce	28	50	1400
2,5	Filter Mass (Particle size 1.4 - 2.4mm)	T	140	350	49000
2,6	Slurry Product (Polymer)	Bag	56	350	19600
2,7	Mud Product (Be tonic)	Bag	28	50	1400
2,8	Original nylon rope Ø 20 mm	Roll	28	140	3920
2,9	Gray cement	Bag	70	10	700
2,10	Diesel	L	14,7	1000	14700
2,11	Sae 50	L	350	4	1400
2,12	Sae 90	L	840	5	4200
2,13	Red Hydraulic Hydra 62	L	1400	3,5	4900
2,14	Fat	Kg	280	5	1400
	Subtotal 2				287280
3	Acquisition of Materials				
3,1	Provision of the sounder	FF			
3,2	Provision of the Compressor	FF			
3,3	Provision of a water tank	FF			
3,4	Air lift injection	Hour	336		
3,4.1	Diesel	L	2800	1,05	2940
3,4.2	PVC tube DN 1" 1/2 + Accessory	Roll	28		
	Subtotal 3				2940
4	Water Quality Analysis	U	42	300	12600

4,1	Drill head construction	U	14	500	7000
4,2	Electro-Mechanical Equipment/pump and accessories (Q=5 m3/h; Hm=150 m and P= 3 HP)	Kit	14	3000	42000
	Subtotal 4				61600
5	Super metal structure				
5,1	Metal Tower 10 meters high	U	14	7000	98000
5,2	Supply and installation of 20 m3 tank	U	14	14000	196000
5,3	Distribution network of 2800 meters with 8 fountain terminals				
	Subtotal 5				294000
	GENERAL TOTAL (EUR)				**680820**

The total cost of carrying out this project is 680 820 €. If such a budget is granted to us, we are sure that it will benefit this population.

CONCLUSIONS

The objective of this work is to provide the population of the Mokali quarter with drinking water of sufficient quality and quantity, both in the present and in the future by 2049.

Indeed, after analyzing the existing situation of the site, we noted that the latter has a problem with sufficient water production. As a result, we carried out a very in-depth demographic study of the said neighborhood, which revealed the evolution of the population and the latter made it possible to estimate the need for drinking water and by calculating the flow in twenty-five (25) years.

In doing so, we propose supplying this quarter by capturing groundwater. Everyone is aware that groundwater is known to be of good quality and certification of this quality before distribution will be ensured by an approved laboratory. Pumping from these boreholes to the elevated reservoir will be carried out by motor pump units operated by electrical energy.

Then, based on these data, we proposed fourteen (14) boreholes of 120 m each and whose operating flow rate of each is 30 m^3/h, suitable for our project flow rate, estimated at 119.97 l/s or 431.89 m^3/h which will be installed in well-studied points of the site; then dimensioned a reservoir of 2185 m^3 volume, which supplies the city all day long. We then carried out a hydraulic calculation of the drinking water distribution network after evaluating the flow rates for each section.

This scientific work, which could still be the subject of more in-depth studies, constitutes our contribution to overcoming the problem of water shortage in our study site, the Mokali district with a view to ensuring good socio-sanitary development of the area but also a source of revenue for the state after invoicing for the service

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