SUSTAINABLE MANAGEMENT OF WATER SUPPLY NETWORKS IN AMAWBIA, ANAMBRA STATE, NIGERIA

O. I. Odumodu[1]

[1]*Civil Engineering Department, Federal Polytechnic, Oko, Anambra State, Nigeria*

Abstract

This work addresses the sustainable management of water supply given one or more sources of water supply for the Amawbia Water Scheme which is under the Awka Water Scheme of the Anambra State Water Corporation, Awka. The viable cost for water supply and distribution in the study area shall be determined which takes into account the annual operation and maintenance costs.This shall help the Anambra State Water Corporation, Awka, the responsible water agencyfor this water scheme to stay in business as it faces the challenges of competing water vendors in Amawbia and environs. The annual costs for the operation and maintenance is forty two million, four hundred thousand naira only (N42.4m) for the unit treatment processes of sedimentation, coagulation and flocculation, filtration, metals removal and disinfection. The accruable annual revenue which is one hundred and twenty six million, seven hundred and twenty thousand naira only (N126.72m) shows that the water scheme is sustainable and viable if properly managed by the responsible water agency.

Keywords: *Sustainable, Management, Cost, Water, Operation and Maintenance.*

---***---

1. INTRODUCTION

One- third of the earth's population lives in 'water- stressed countries and that number is expected to rise over the next two decades. Often, water has to be carried long distances to the house which takes extraordinarily long time and effort, a burden borne mainly by women and children' (www.ProjectConcern.org/WWD09)[1]. This view was highlighted during the 'San Diego Walk for Water' on the World Water Day on March 22nd, 2009 , organised by Project Concern International, San Diego, USA (see Fig.1). The United Nations General Assembly, in December, 2003, proclaimed the year 2005- 2015 as the International Decade for Action 'Water for Life'(http://www.unwater.org/events.html)[2]. "Today, almost half of the world's workers- 1.5 billion people- work in water related sectors and nearly all jobs depend on water and those that ensure its safe delivery". This view was got from World Water Day, 2016- caption of Better water, better jobs (www.unwater.org/worldwaterday)[3]. These proclamations buttress the adage: 'water is life'. Water is, in fact, one of the basic necessities of life (Punmia et al, 2003)[4].

Fig. 1: Participants during San Diego Walk for Water in March 2009

The aim of this work is to investigate the sustainable management of water supply network to meet the water needs of Amawbia Community using Amawbia Water Scheme under the Awka Water Scheme of the Anambra State Water Corporation, Awka, Anambra State, Nigeria using surface and/ or ground water resources.

1.1 Backrgound to Study Area (See Fig.2)

Amawbia is within the Awka Capital Territory of Anambra State, Nigeria. It lies within the rainforest region of Nigeria characterised by equatorial tropical climate with both seasonal and diurnal weather changes (Barbour et al, 1982)[5]. Maximum monthly rainfall during the peak periods range from 270mm to 360mm, with an average annual rainfall of 2000mm.

Residents of Amawbia, Anambra State, Nigeria have suffered untold hardships to access potable water. Childrenand women had to fetch water from village streams; others trekked to borehole points (mainlyshallow boreholes) to pay for and collect water in buckets and plastic containers. Those who couldafford, paid water vendors to supply water in storage tanks for their use.The construction of the Amawbia Water Scheme is consequently a welcome development.

1.2 Theoretical Aspects

Nwaogazie and Ologhadien, (2005)[6], applied WASDIM software for the design of water supply and distribution system for theUniversity of Port Harcourt three campuses in South-South, Nigeria. They applied the governing equationsof Hardy Cross technique thus:

$$\Delta H = 2\Delta Q \Big/ \sum Q/h_L \qquad (1)$$

where: ΔH = headloss correction; Q = discharge through the pipe; h_L = head loss in the pipe system.

Anyata (1980)[7], used the Hazen- William's headloss equation, the general energy equation and prevailing energy tariff to obtain total daily pumping cost (in dollars) thus:

$$C_{Tot} = K_{op} L_{lj}\, Q_{lj}^{2.85} \Big/ d_{lj}^{4.87} \qquad (2)$$

where, $K_{op} = 4.17 * C_S * 62.4 * 0.746 *$ pumping hours/ day/ $550 * n_p * C_{HW}^{1.85}$ (3)

L_{lj} is the length of pipe between nodes l and j; Q_{lj} is the discharge between nodes l and j in imperial units;d_{lj} is the pipe diameter; C_{HW} is the Hazen- William's coefficient of the pipe between nodes l and j. A value of 100 for C_{HW} was used for the study (Anyata, 1980); np is the efficiency of the pumps/ motors; Cs isthe unit cost of electricity (in $/kWH).
The Hazen- William's equation for headloss is givenby (Walski et al,2003)[8]:

$$h_L = 10.7 * Q_{lj}^{\ 1.852} * L_{lj} \Big/ C_{HW}^{\ \ 1.852} * d_{lj}^{\ 4.87}$$ in S.I. units; (4)

The general power equation is given by:

$$\Delta P = \gamma H\, Q/n \qquad (5)$$

For this work, the total pumping cost for all nodes in the network (in naira), is given as:

$$C_{T1} = (\rho g * 10.7 * Q_{lj}^{1.852} L_{lj} Q_{lj} \Big/ 1000 * n * C_{HW}^{1.852} * d_{lj}^{4.87}) * t * C_{en} \qquad (6)$$

for nodes at same elevation b/w supply point anddelivery point or .

$$C_{T2} = (\rho g / 1000 * n) * t * C_{en} * Q_{lj} * (H_e + h_L) \qquad (7)$$

where He is difference in elevation b/w supply pointand delivery point. A value of 120 for C_{HW} is used for this study; n = 0.8is used as the efficiency of the pumps/ motors; Cen isthe unit cost of electricity, in N/kWH = N25.00/ kWH; (EEDC, 2016)[9].

2. METHODOLOGY

Data were collected through: (a) Literature reviews related to the study (b) Appraisal of the proposed water scheme in Amawbia and environs (c) field measurements including population studies, distances and elevations; (d) administration of interviews.

Low lift pumps include: No. 1 Pump, of capacity 30hp (faulty) ; No. 2 Pump, of capacity 30hp; No. 3 Pump, of capacity 50hp; No. 4 Pump, of capacity 20hp; No. 5 Pump, of capacity 40hp. At present, four pumps are functional; two pumps feed the surface/ ground tanks (of total capacity $200m^3$) simultaneously while the other two are on standby and subsequently alternate the supply to the ground tanks.

High lift or booster pumps include: 2 No. pumps of capacity 110 Kw each (capacity, $200m^3$/ hr: takes about 45 minutes to one hour to fill overhead tank, OHT, at Ugwu Tank).Borehole yield was not availble. One booster pump works at a time while the second one which is on standby subsequently alternates the supply to the overhead tank, OHT.

The standby generating set is of capacity 300kVA as alternative power supply serving both the low lift and high lift pumping stations.

The reservoir at Ugwu Tank is of capacity $150m^3$((ASWC, 2014)[10].

Total capacity of ground/ surface tanks at pumping station is $200m^3$.

Supply pipes to OHT are of 200mm diameter (ϕ), distribution pipes are of 100mm ϕ.

Population of Amawbia is got from Table 1 (N,P.C., Awka; 2014)

Proposed water tariff for $1m^3$ = ₦200.00 (A.S.W.C., 2014).

Water tariff for $1m^3$ = ₦250.00 to ₦500.00 (average rate by private developers).

Table 1: Population Figures for Amawbia and environs for Awka Water Scheme (National Population Commission (NPC)[11], Awka; 2014: 1991 Census)

Town	Yr 1991 (NPC) Figure	Yr 2015 Projection with 3.1% growth rate	Yr 2030 Projection with 3.1% growth rate
Awka	58,225	118,360	184,402
Amawbia	14,389	29,250	45,571
Okpuno	3,498	7,111	11,079
Amansea	2964	6,026	9389

Table 2: OPERATION AND MAINTENANCE COST FOR AN AVERAGE DAILY INFLOW OF 10,000 cu. m / day (Adapted from Odumodu and Ekenta, 2012)[12]

	COST ITEMS	**COST(N) x 1000**
1	Chemist: 2	
	1 chemist: fresh graduate at N360000 per annum	360
	1 senior chemist at N480000 per annum	480
2	Technicians: 2	
	1 junior operator at N240000 per annum	240
	1 senior operator at N300000 per annum	300
3	Mechanics	
	2 mechanics at N180000 per annum	360
4	Ordinary labourers: 10	
	6 labourers at N120000 per annum	720
	2 labourers at N180000 per annum	360
	2 gang leaders (labourers) at N210000 per annum	420
5	Engineers: 4	
	1 electrical engineer at N480000 per annum	480
	1 mechanical engineer at N480000 per annum	480
	2 civil engineers at N480000 per annum	960
6	Maintenance supervisors: 2	
	1 junior supervisor at N180000 per annum	180
	1 senior supervisor at N240000 per annum	240
7	Other staff	
	1 General Manager (GM) at N2.4m; 1 secretary at N360000;	
	2 clerks at N240000; 2 messengers at N180000; 2 billing staff	
	at N240000; 3 accountants at N480000 per annum respectively	5520
	SUBTOTAL	**11100**
8	Fuel, grease and lubricants, 5%, say	555
9	Medical Services National Health Insurance Scheme (NHIS), 5% of annual salary	555
10	Pension Fund: 7.5% of annual salary	832.5
11	Training and Bonus allowances:5% of annual salary	555
12	Chemicals **(Anyata and Obiasor, 2006)[13]:**	
	Cost of treating 10,000 cu. m of water is say:	8148.15
13	**Add 10% Inflation for 9 Years (2006-2015) (10000/135000X110/1)(1+10/100) ^{9} = N19,213,000**	19213
14	Contingencies: 10% of annual salary, say	111.0
15	Power Cost	
	The power required for an average daily inflow of 10000 cu.m per day	
	or 0.12 cu.m per sec. is given by: PQHg / n; where	
	ℓ = density of water = 1000 kg/ cu. m; g = acceleration due to gravity = 9.81 sq.m;	
	Q= daily inflow = 0.12 cu.m per sec; h = change in elevation = 70m;	
	n = pump efficiency = 80%, say.	
	P = 1000 x 9.81 x0.12 x70/ 1000 x0.8 = 103Kw	
	For 1 year, power required = 103 x 12 x 365 = 451140kW- hr, for 12hrs pumping/ day	
	Annual power cost = 451140 x 25 = N11278500 (EEDC 2016, Rate)	11278.5
16	**TOTAL = N42,358,150; say N42.4m**	**42358.15**

3. RESULTS AND DISCUSSION

WATER DEMAND FOR AMAWBIA SCHEME IS GIVEN BY:

Water consumption =120li/c/day **(Izinyon, 2006)[14]**

Present water demand for Amawbia Water Scheme, (2015) is given by:

120 x **29,250** = 3510000 li/day or 3510m^3/day; add UFW (30%) to get Amawbia Water Scheme Demand: 1.3x3510 = 4563 m^3/day, say, 4600m^3/day. Present Water demand = **4600 m^3/day**

See Table 2 for Operation and Maintenance cost for AmawbiaWater Scheme..

(i) the actual average quantity of pumped water per day for the Amawbia Water Scheme is 2,4**00 m^3/day (200 m^3/hr** from two boreholes simultaneously for 12 hours per day). The capacity of the OHT is 150m^3, hence, some distribution lines shall be allowed to receive water from direct pumping than by gravity from the OHT (Odumodu, 2013)[15].
(ii) the total pumped/ available water is only 52% of the total daily requirement (2,400 m^3 as against 4,600 m^3). There is need to increase this through the reactivation of Okika Spring water which runs and wastes away '24/ 7 ', i.e., 24 hours a day, 7 days, a week. This Scheme, very close, to the treatment plant or Borehole House at Amawbia, is dilapidated but could be reactivated and adjoined to the new Amawbia Water Scheme. Again, the daily demand could be increased by increasing the hours of pumping per day from 12 hours to 15hrs or 18hrs per day. The shortfall of 2,200 m^3/ day, for now, could be augmented by private water vendors. This is also welcome since they will remain in business and also provide the much needed fillip for competition! There exist, as well, many individual and public boreholes for some private homes and public places like markets and schools to further augment the shortfall.For future, however, the proposed Awka (surface) Water Scheme (Zone 1), if implemented, will adequately cater for the total daily water demand for Awka and environs, including the Zone 2(Amawbia Water) Scheme.

Expected Revenue Year (2015)

Present water available = 2,400m^3/day. Proposed Tariff = **N200/m^3**

Recorded days= 22days (toallow for break downs, repairs etc.)

Revenue will be: 2400x200x22 x 12 = **N126.72m**.

Fig. 2 shows the water distribution network for Amawbia (Zone 2) Water Scheme, The annual cost of operation and maintenance **(O and M)** of the scheme is **N42.4m (see Table 2) while the annual accruable revenue is N126.72m.** It should be noted that annual cost does not include construction cost. This is a government scheme with envisaged benefits to the public which includes job creation and cost reduction in amenities. However if proper management is lacking, this scheme might collapse as with past water and other government projects.

Projected water demand for Amawbia Water Scheme, (2030):

120 x 45,571 = 5,468,520 li/day or 5469 m^3/day; add UFW (30%) to get Amawbia Water Scheme Demand: 1.3x5469 = 7110m^3/day, say, 7200 m^3/day. **Projected water demand** = 7,200 m^3/day

As already stated for the case of the present demand, the projected demand cannot be met by the available boreholes nor the pumping hours. The shortfall of 4,800m^3/day may be provided by sinking of four addional boreholes or by private water vendors or by the proposed Awka (surface) Water Scheme.

Projected Revenue is expected to make the scheme viable if additional boreholes are sunk or the Okika Spring Water is reactivated. This is more so since the only available water of 2400m^3/day is viable for Year 2015. Cost of 250mm diameter borehole of 90- 100m depth is N3.0m (ASWC, 2014)

The annual worth (amortised cost) of four addional boreholes is given by:

$A = P*(i(1+i)^N / (1+i)^N - 1)$ (DeGarmo et al, 1979)[16].

Where P = present worth of 4no. boreholes = N12.0m; i = interest rate, say, 15%

N = plan period, i.e., 15 years. Hence, A = $12*(1.15)^{15}$**/**$(1.15^{15}$—1) = N13.68m
Hence new **O and M** cost will be N42.4m + N13.68m = N56.08m. The scheme is still viable even without increasing the tariff or amortising the present annual revenue of N126.72m!!

4. CONCLUSION

The Government of Anambra State through the Anambra State Water Corporation (ASWC) Awka is reactivating the Amawbia Water Scheme under the Awka Water Scheme.From the estimated population of 29,250 using a per capita demand of 120li/capita/day, water supply from the existing boreholes is not adequate. Theannual operation and maintenance (O and M) cost of available water from the scheme isN42.4m (forty two million and four hundred thousand naira only). The annual accruable revenue is N126.72m(One hundred and twenty six million seven hundred and twenty thousand naira only). The scheme is sustainable and viable if properly managed. The Okika Water Scheme, very close, to the treatment plant or Borehole House at Amawbia, is dilapidated but could be reactivated and adjoined to the new Amawbia Water

Scheme to meet water demand. Again, the daily demand could be increased by increasing the hours of pumping per day from 12 hours to 15hrs or 18hrs per day. The shortfall of 2,200 m^3/ day, for now, could be augmented by private water vendors. This is also welcome since they will remain in business and also provide the much needed fillip for competition! There exist, as well, many individual and public boreholes for some private homes and public places like markets and schools to further augment the shortfall. For future, however, the proposed Awka (surface) Water Scheme, if implemented, will adequately cater for the total daily water demand for Awka and environs, including the Amawbia (Zone 2) Water Scheme.

REFERENCES

[1] www.ProjectConcern.org/WWD09

[2] http://www.unwater.org/events.html

[3] www.unwater.org/worldwaterday

[4] Punmia, B.C.; Jain, A.K. and Jain, A.L. (2003): Water Supply Engineering (Laxmi Pubs (P) Ltd.; New Delhi-11002; pp. 1-2).

[5] Barbour, B.K.; Oguntoyinbo, J. S. Onyemelukwe, J.O.C. and Nwafor J.C. (1982): Nigeria in Maps (Hodder and Stoughton (Educational) Ltd. Publishers Services Ltd., Ibadan).

[6] Nwaogazie, I.L. and Ologhadien I. (2005): Water Distribution Network Modelling of University of Port Harcourt Three Campuses ; NSE Technical Transactions- A Publication of the Nigerian Society of Engineers (NSE); July-Sept. 2005; Vol. 40, No. 3.

[7] Anyata, B.U. (1980): Investment Alternatives in Cases of Extended Water Supply Shortages in Cities of Developing Countries doctoral dissertation- Dept. of Civil and Environmental Engineering, Cornell Univ., Ithaca, New York, USA.

[8] Walski, T.M.; Chase, D.V.; Savic, D.A.; Grayman W.; Beckwith, S.; Koelle, E. (2003): Haestad Methods; Advanced Water Distribution Modeling and Management1st Ed.; Haestad Methods Inc.; Haestad Press; Waterbury, CT, USA; pp. 34, 134-137.

[9] Enugu Electricity Distribution Company, EEDC (2016): Proposed new electricity tariff, January, 2016.

[10] Anambra State Water Corporation (A.S.W.C.), (2014): Interviews with the Acting General Manager of Anambra State Water Corporation, Awka and other key staff of the Corporation on different dates.

[11] National Population Commission (NPC), Awka (2014).

[12] Odumodu O. I. and Ekenta E. O. (2012): Modelling Operation and Maintenance Management of Water Supply in Awka, Anambra State, Nigeria; Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 3(5): 868-873© Scholarlink Research Institute Journals, 2012 (ISSN: 2141-7016).

[13] Anyata, B.U. and Obiasor, C. (2006): Availability Analysis of Chemicals for Water Treatment: An Application to Edo and Anambra States Water Utilities Boards; Nigerian Journal of Technology; Vol. 25, No. 1, March 2006; ISSN 1115-8443.

[14] Izinyon,O.C.(2006): Hydraulic Performance Evaluation of An Urban Water Supply System A Case Study of Ikpoba Hill District Network; Unpublished Ph.D. Dissertation, Department of Civil Eng., Univ. of Benin, Benin-City, Nigeria.

[15] Odumodu, (2013): Modelling the Sustainable Management of Water Supply Network in Awka and Environs, NigeriaUnpublished doctoral. dissertation, Department of Civil Eng., Nnamdi Azikiwe Univ.Awka, Anambra State, Nigeria.

[16] DeGarmo, E.P.; Canada, J.R. and Sullivan, W.G (1979): Engineering Economy Macmillan Publishing Co., Inc.; 3rd Avenue, New York, New York 10022; 6th Ed., pp. 63- 77.

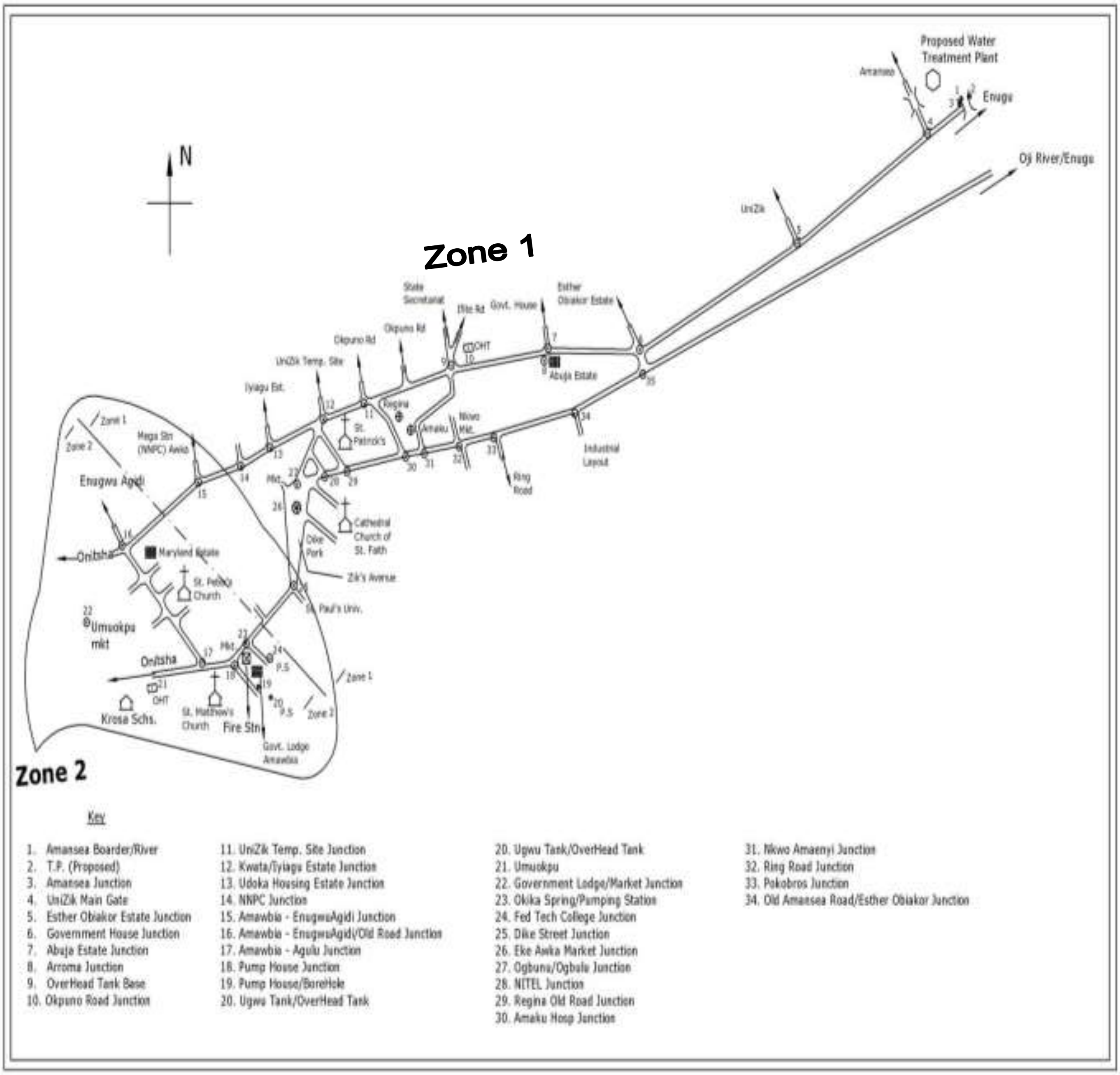

Fig. 2: WATER SUPPLY AND DISTRIBUTION NETWORK FOR (ZONE 2) AMAWBIA WATER SCHEME