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# PRODUCTIVITY OF SOME WATER WELLS IN THE ALLUVIAL SEDIMENTS OF LAKE CHAD

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## ABSTRACT

*The performance of ten (10) water supply boreholes drilled in the quaternary sediments of the Chad Formation at Nguru, Yobe state have been evaluated using the Step draw down test (SDDT). Pertinent hydraulic characteristics such as aquifer and well loss coefficients, specific capacity and transmissivity of the wells and aquifer tapped were also determined using regression techniques. Results show that the specific capacity of the wells range between 9.3 and 261 m²/day, aquifer loss range from 1.61 – 19.57m, well loss range from 0.25 – 4.49m and Transmissivity of the tapped aquifer range from 13m²/day – 356m²/day. The efficiency of the wells used as the performance criteria range from 51.1% - 89.1%, indicating satisfactory performance. The highest draw down of 24.56 m was observed in well NG27, this well was also found to have the least transmissivity of 13m²/day, it is suspected that this well was badly developed after construction. The result obtained shows that most of the boreholes are still productive. The performance should be updated annually in order to guarantee future supply of water. The result of the study is expected to be a reference for future well testing program in the area.*

**Key words**: water wells; pumping test; productivity; efficiency.

## INTRODUCTION

The step draw down test (SDDT) is a major tool for both aquifer and well evaluation especially when there are no observation holes and the data has to be analyzed. The test simply involves the observation of the draw down from a well while the discharge rate from the well is increased in steps. The discharge rate is kept constant through each step.

The SDDT has been used to analyze the performance of wells in both confined and unconfined aquifers. Clark (1977) summarized methods of analyzing data from SDDT and calculation of the aquifer and well loss coefficients B and C.

The underlying equation guiding the test is the Jacob's equation:

$$S_{wc} = BQ + CQ^2 \qquad \text{----------} \quad (1)$$

This implies that the total draw down in a well $S_{wc}$ is composed of the aquifer loss BQ and well loss $CQ^2$ (Sheikh, 1991). The well loss results from resistance to turbulent flow in the zone adjacent to the well, and through the screen. The aquifer loss is that part of the draw down caused by resistance to laminar flow within the aquifer.

Analysis of the test data involves the evaluation of the aquifer and well loss coefficients B and C. Solutions of the Jacob's equation are mostly graphical, the computations involved in these solutions are, however, tedious, computer programs are now available to handle the calculations (Shashank, 2006).

The graphical approach involves dividing Equation 1 by Q to yield:

$$\frac{S_w}{Q} = B + CQ \qquad \text{- - - - - - - - - - - - - --- - (2)}$$

An arithmetic plot of $S_w/Q$ (specific draw down) against the discharge Q will give a straight- line graph with a slope C and intercept B. The evaluation of well loss enables the efficiency of the well to be calculated. Well efficiency ($E_w$) is the ratio of aquifer loss to the total draw down in the pumped well and can be expressed as follows:

$$E_w = \left( \frac{BQ}{BQ + CQ^2} \right) \times 100\ \% \qquad \text{------- (3)}$$

It should be noted that a good well design can minimize well loss in a given situation but never eliminate them and comparison of well efficiencies is not really valid unless the wells are virtually identical; this is the case with wells in the Chad basin formation.

One reason for conducting SDDT is to enable the well loss to be evaluated when there is no observation hole and the data from the pumped well had to be analysed. Walton (1962) has illustrated the significance of the well loss coefficient as shown in Table 1; the value of the well loss coefficient elucidates the level of deterioration of the well in question.

**Table 1: Relation of well loss coefficient to well condition**

| Well loss coefficient C (min2/m5) | Well condition |
|---|---|
| < 0.5 | Properly designed and developed |
| 0.5 - 1.0 | Mild deterioration due to clogging |
| 1.0 - 4.0 | Severe deterioration or clogging |
| > 4.0 | Difficult to restore well to original capacity |

**(**Walton (1962)

The transmissivity of the aquifers can be calculated from the first step of the test, after the draw down data has been corrected for well loss, using either the equilibrium or Theis equation as appropriate. Alternatively, an approximate equilibrium analysis may be conducted using the following equation:

$$T = 1.2\ Q/\ S_w = 1.2\ /\ B \quad ----------\ (4)$$

This equation is particularly suited for wells in alluvial plains (Logan, 1964). If discharge is divided by draw down in a pumping well $Q/S_w$, the specific capacity is obtained. This is a measure of the productivity of the well; clearly, the larger the specific capacity, the better the well.

The purpose of the study was to evaluate the performance of ten water supply wells drilled in the upper zone pressure aquifer of the Chad formation at Nguru and to determine some hydraulic constants of the tapped aquifer

***Study location***

The study was carried out at Nguru in Yobe state, Nigeria on Latitude $12^0\ 52^1$ N, Longitude $10^0\ 27^1$ E, within the Komadugu Yobe River sub catchment of the Lake Chad basin (Sobowale, 2005). The town is situated in the flood plains (Fadama) of the Hadejia River as shown in Figure 1; it is devoid of rock outcrops and is largely covered by superficial deposits of sand and clay (Alluvial sediments). All drainage is towards Lake Chad; the waters are dissipated in broad swamps and lost by evaporation or transpiration or by percolation to the underlying aquifers.

## MATERIALS AND METHOD

The test was designed to be in four (4) steps, each step lasting for two hours and followed by a two hours recovery test. The discharge rates in the ten (10) boreholes were measured using flow meters and time to fill a container of known volume, water level was measured using an electric sounder (water level indicator) graduated to measure depth to water in the well. The discharge rates were increased with step increments and water level readings taken at 1,2,3,4,6,8,10,15,20,30,50…120 minutes in each step. Grundfos submersible pumps were used in the tests. The draw down and discharge data obtained from the pumped wells were analyzed using regression techniques to obtain values of aquifer loss and well loss coefficients, specific capacity, well efficiency and transmissivity.

## RESULTS AND DISCUSSION

The technical data of the tested wells are presented in table 2.The results obtained from the tests are also presented in table 3 and figure 2. The specific capacity of the ten boreholes ranges from 9.3 $m^2$/day – 261$m^2$/day, hence the borehole NG1 is the most productive of the ten boreholes. A reduction in specific capacity of a well can be attributed to either the reduction in transmissivity due to lowering of ground water level in an unconfined aquifer or to an increase in well losses associated with clogging or deterioration of the well screen.

Figure 3 shows that there is a good fit between observed draw down in the wells and the computed draw down when the regression equations were used. A comparison of the Aquifer losses and Well losses in the wells shows that most of the draw down in the wells was due to the aquifer loss component especially in borehole NG 23 and NG 27 (Figure 4).

Borehole NG 1 has the highest efficiency and transmissivity of 89.2% and 356m$^2$/day, respectively. NG24 has the least efficiency of 51.1%. It is suspected that this is due to the clogging or deterioration of the well screen, the aquifer loss component of the draw down is just slightly higher than the well loss component. A perfectly efficient well, with perfect well screen and where the water flows inside the well in a frictionless manner would have 100% efficiency. Unfortunately, well efficiency is hard to compare between wells because it depends on the characteristics of the aquifer too (the same amount of well losses compared to a more transmissive aquifer would give a lower efficiency).

The three boreholes, NG24, NG25, and NG26$^A$ are least efficient; further evaluation revealed that they all tap into the same aquifer which has a low yield, hence can only be used to supply water to a small population. However, they need to be inspected with closed circuit TV camera to determine the extent of damage or clogging of the screen in order to determine appropriate rehabilitation measures.

## CONCLUSION

Step draw down tests are used principally to determine the well losses and well efficiency, but they can also be used to determine transmissivity. The result of the performance of the wells is a major reference for future well testing programs and also will be a supplement and check for the analyses of a constant discharge test for the wells. Most of the wells evaluated can still guarantee future water supply at the community level; this tests should be carried out annually in order to track the performance of the wells, this will make it possible to develop a maintenance schedule for the wells

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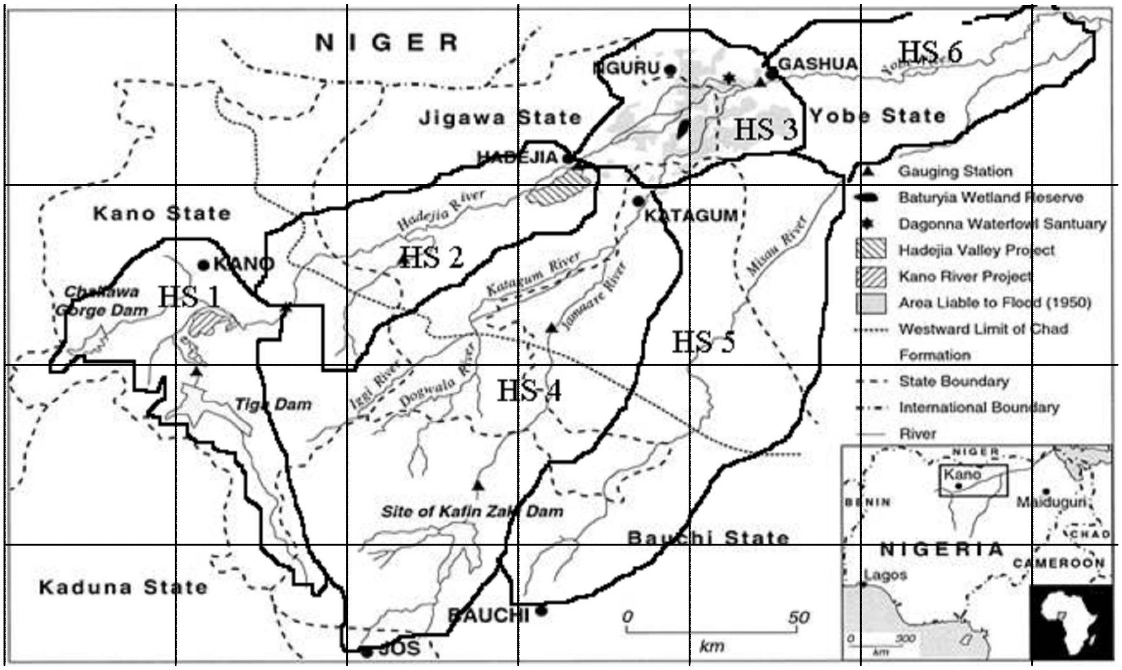


**Figure 1: Location map of the study site (Sobowale, 2005)**

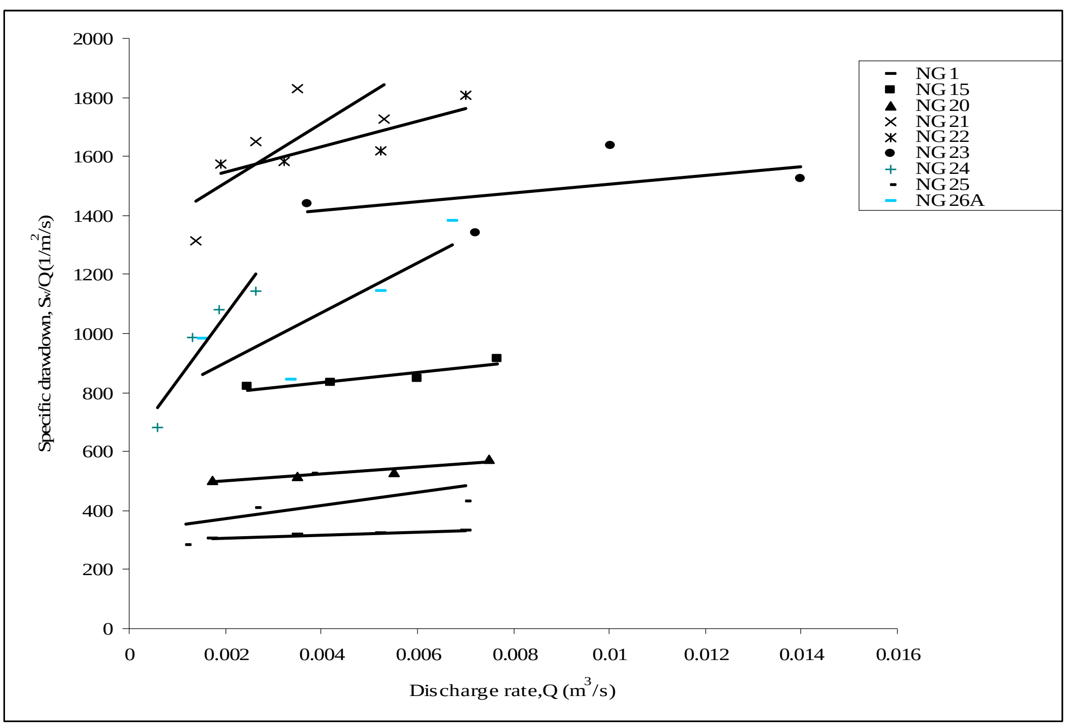


**Figure 2: Plot of $S_w/Q$ versus Q of field data from step - drawdown test**

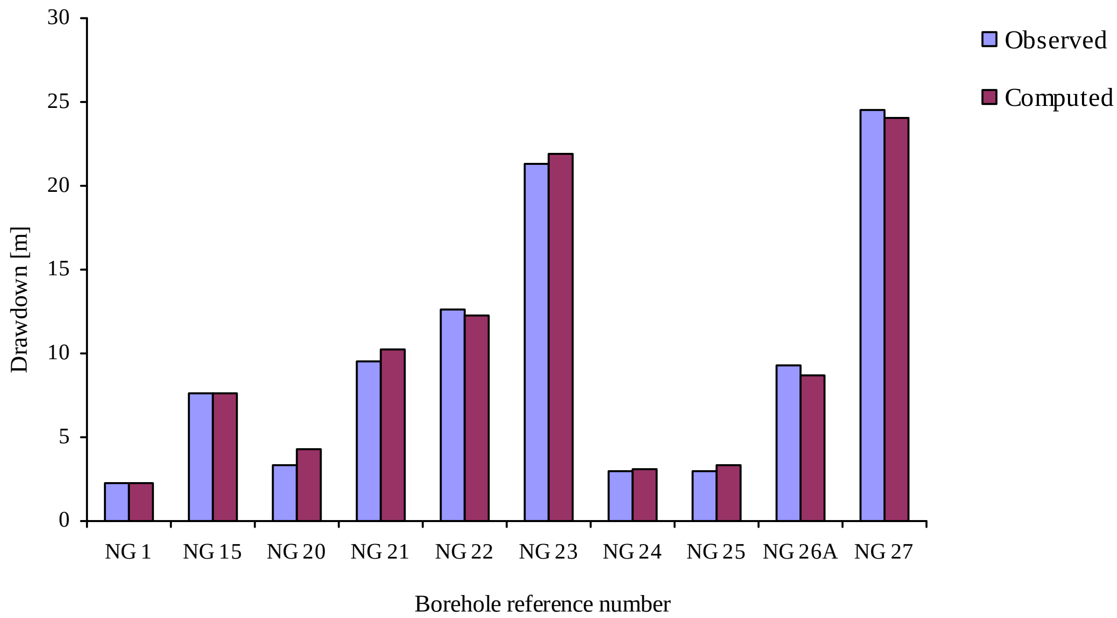


**Figure 3: Comparison of observed and computed drawdown**

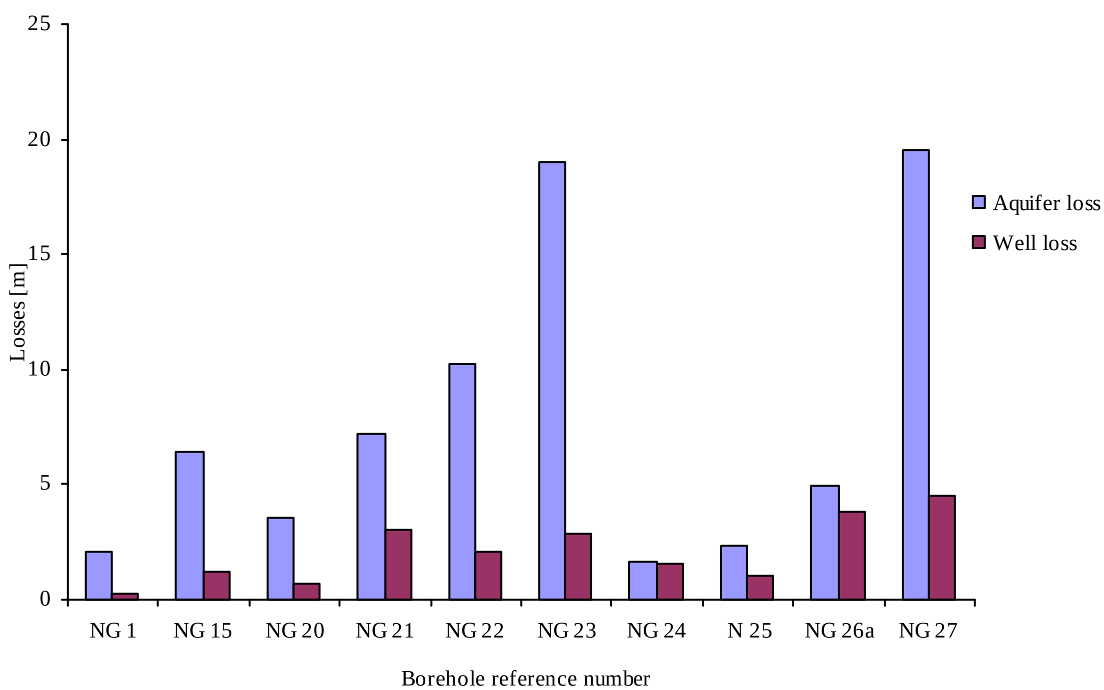


**Figure 4: Comparison of Aquifer and Well losses**

**Table 2:Engineering data of tested wells**

| Well No. (Ng…) | Total Depth (m) | Pump Inst. Depth (m) | Cas-ing Size (In) | Pump Size (Hp) | Pump Type (Grundfos) | Static Water Level (m.b.G.l.) | Pumped Yield (m3/s) 10 -3 | Draw down (m.b.St.W.l.) | **Location** |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 54 | 24 | 6 | 10 | SP16-16 | 9.26 | 7.0 | 2.32 | Y.S.W.B. Premises, Nguru. |
| 15 | 48.2 | 30 | 8 | 15 | SP27-11 | 8.75 | 8.40 | 7.67 | Along G.R.A. Road. |
| 20 | 54 | 24 | 8 | 20 | SP45-12 | 7.90 | 7.50 | 3.31 | Behind Nguru L.G.A. Office. |
| 21 | 62.2 | 24 | 8 | 10 | SP16-16 | 8.40 | 5.51 | 9.54 | Industrial Estate |
| 22 | 71.4 | 30 | 8 | 15 | SP27-11 | 8.40 | 7.00 | 12.66 | “ “ |
| 23 | 61 | 36 | 8 | 20 | SP45-12 | 9.15 | 14.00 | 21.34 | “ “ |
| 24 | 60 | 18 | 6 | 5 | SP8-21 | 6.60 | 2.63 | 3.01 | Women Teacher’s College. |
| 25 | 54 | 24 | 6 | 10 | SP16-6 | 8.65 | 7.00 | 3.01 | Primary School. |
| 26A | 54 | 24 | 6 | 10 | SP16-16 | 8.4 | 6.73 | 9.30 | Right side of the town’s bridge. |
| 27 | 54 | 36 | 6 | 5 | SP8-21 | 9.58 | 2.63 | 24.56 | Eid Ground. |

**Table 3: Result of pumping test analyses**

| Well No. NG | Observed Dd Sw (m.b.st.w.l.) | Discharge Qx10-3 (m3/s) | Specific Dd Sw/Q (m/m3/s) | Specific Cpty Q/Sw (m2/day) | Aquifer loss Coeff. B (sec/m5) | Well loss Coeff. C (s2/m5) | Aquifer Loss (m) | Well Loss (m) | Computed Dd Swc (m) | Well Eff. % | Trans. T (m2/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.32 | 7.00 | 331 | 261 | 296 | 5200 | 2.07 | 0.25 | 2.32 | 89.2 | 356 |
| 15 | 7.67 | 8.40 | 913 | 95 | 767.9 | 16736 | 6.45 | 1.18 | 7.63 | 84.5 | 135 |
| 20 | 3.31 | 7.50 | 441 | 196 | 475.2 | 12158 | 3.56 | 0.68 | 4.24 | 83.9 | 218 |
| 21 | 9.54 | 5.51 | 1731 | 50 | 1304.7 | 101258 | 7.18 | 3.07 | 10.25 | 70 | 79 |
| 22 | 12.66 | 7.00 | 1809 | 48 | 1458.6 | 43108 | 10.21 | 2.11 | 12.32 | 82.8 | 71 |
| 23 | 21.34 | 14.0 | 1524 | 57 | 1355.9 | 14799 | 18.98 | 2.90 | 21.88 | 86.7 | 76 |
| 24 | 3.01 | 2.63 | 1144 | 75 | 613.7 | 223289 | 1.61 | 1.54 | 3.15 | 51.1 | 327 |
| 25 | 3.01 | 7.0 | 430 | 201 | 330.5 | 22080 | 2.31 | 1.08 | 3.39 | 68.1 | 313 |
| 26A | 9.30 | 6.73 | 1382 | 63 | 730 | 84598 | 4.91 | 3.83 | 8.74 | 56.1 | 142 |
| 27 | 24.56 | 2.63 | 9338 | 9.3 | 7442 | 650240 | 19.57 | 4.49 | 24.08 | 81.2 | 13 |

m.b.st.w.l.= meters below static water level Dd= Draw down Cpty= Capacity Coeff. = Coefficient Eff. = Efficiency Trans. = Transmissivity