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Evaluation of Aquifer Performance Using A Pumping Test of Boreholes Drilled In Different Part Of Mubi And Environs, North-Estern, Nigeria.

KASIDI S.
Department of geology, Adamawa state University, Mubi

Abstract: *Aquifer performance test was carried out for six borehole within Maiha, Mubi North andMubi-south Local government area. The Boreholes were tested using a constant rate and recovery Phase so as to ascertain the recharge rate of each Borehole. The depth of each borehole tested are 24m, 25.43m, 40.3m, 58.5m, 61.5m, and 63.2m. Their discharge rate are 0.27 l/s, 0.43 l/s,0.46 l/s, 0.46l/s, 0.8l/s and 1.05l/s. Physiochemical parameters of the water measured in this boreholes are within the permissible limit of the World Health Organization(WHO). Based on the pumping test these wells were installed at recommended depths and pumps they have good yield and are currently productive.*

Key Words: *Pumping test, Borehole, recharge, Aquifer, recovery phase and Ground water*

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I. Introduction

Hydro geologists determine the hydraulic characteristics of water-bearing formations, by conducting pumping tests. Pumping Test is conducted to examine the aquifer response, under controlled conditions, to the abstraction of water. The basic principle of a pumping test is that if we pump water from a well and measure the pumping rate and the drawdown in the well then we can substitute these measurements into an appropriate formula and can calculate the hydraulic characteristics of the aquifer (kasidi and lazarus,2019). It is also called aquifer tests for aquifer parameter evaluation. Groundwater is the most suitable source of drinking water, supplies of which are brought to the surface by drilling boreholesor hand dug wells. Pumping tests are a practical way of obtaining an idea of the borehole's efficiency and its optimal production yield.

Singlewell aquifer tests arefrequently analyzed withtheCooper-Jacob(1946)methodbecauseofitssimplicity.Transmissivityisestimatedbyfittingastraight lineto drawdown on anarithmeticaxis versestimeon alogarithmicaxisinasemi-logplot. Drawdown inconfined and unconfinedaquifers have been analysed by many researchersusingtheCooper-Jacobmethod,regardless ofdifferences betweenfieldconditionsandtheory (Halford,etal,2006; Sulistyo, 2018; Amah andAnam, 2016; Mawlood and Aziz, 2019; Hassanet.al,2016; Chenini,et. al, 2008; Okon et. al., 2018; Schaat, 2004)

AstheCooper-Jacobmethodisasimplificationofthe Theissolution,thepumpingwellshouldfullypenetrate aconfined,homogeneous, andisotropicaquifer.Single well tests from a fully penetrating wellsin unconfined aquifersdepartgreatlyfromtheTheis (1935) model. Moreover,unconfinedaquifertestsareaffected byvertical anisotropy andspecificyieldinadditiontotransmissivity andstoragecoefficient (Kasidi and Lazarus, 2019).These additionalparameterscontrolverticalgradients thatarecreatedby partialpenetrationanddrainagefromthe water table.Likewise,leakage fromadjacentconfiningbedsalsocould affecttransmissivityestimates,which likelywillbeoverestimatedby theCooper-Jacobmethod (Halford,etal,2006).The objective of this paper is To determine the capability of the well and aquifer to provide a reliable yield of water at the desired rate.To evaluate well performance and determine the specific capacity of the well, aquifer transmissivity and yield.

A pumping test consists of pumping groundwater from a well, usually at a constant rate, and measuring water levels in the pumped well and any nearby wells (observation wells) or surface water bodies during and after pumping. A pumping test is a practical, reliable method of estimating well performance, well yield, the zone of influence of the well and aquifer characteristics (i.e., the aquifer's ability to store and transmit water, aquifer extent, presence of boundary conditions and possible hydraulic connection to surface water).

After drilling, it is imperative that the aquifer is evaluated and these are determined by carrying out an aquifer test (pumping test). Six Boreholes drilled two in each Maiha, Mubi –South and Mubi – North Local government area. Pumping test was carried on these Boreholes specifically to ascertain the performance characteristics of the boreholes such as yield, Draw down. Based on the results of pumping test, it is imperative to advice on the type and capacity of pump as well as depth of installation, to obtain maximum utilization of the well.

Location of the study area and Geology

Mubi and environs lie within Latitudes $10^{\circ}08^{1}$N and $10^{\circ}30^{1}$N and longitudes $13^{\circ}10^{1}$E and $13^{\circ}25^{1}$E. It is located some 150km Northeast of Yola and about 25km from the Nigerian - Cameroun border (fig.1).

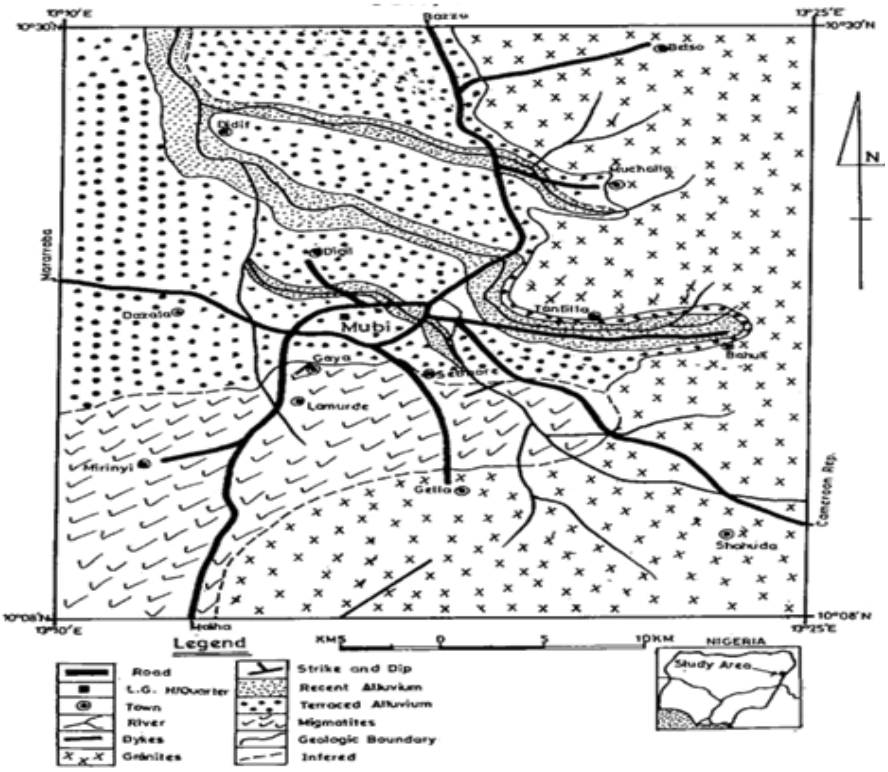

Fig.1. Geological Map of the Mubi and Environs (after kasidi and lazarus 2019)

The town is located within the Precambrian Basement Complex in the Northern part of Adamawa State. The rocks in the area are the Migmatite-gneisses and the Older granites. Some parts of the study area overlying the basement rocks are the alluvial deposits, which are derived from the weathering of the basement rock uphill and in situ. Geologic log data indicate that the thickness of the alluvial deposits to the bedrock range from about 5m to 25m along the river Yedsarem(Kasidi and Lazarus 2019).The area is made up of two aquifer systems based on the drilled holes. These are the fractured basement (mainly granitic) and overburden

II. Methodology

The methods employed during the test are Constant rate and Recovery Phase**,** during the discharge stage, the well was pumped at a constant rate, and the water level in the pumped well was measured at intervals. After pumping for eight (8) hours, the well was allowed to recharge and the water level was measured again at the same intervals as that of the discharge stage (American Society for Testing and Materials (ASTM). 1997). The following equipment where used in carrying out the pumping test.

1. 1.0H.P submersible pump and cable
2. Flow meter(to measure volume of water discharged)
3. Depth/water level sounder (for determining the depth and water level)
4. Generator (for powering the submersed pump)
5. Stopwatch (for taking time intervals)
6. Riser pipes
7. Clamp (for holding the risers in place)

The Theis solution was chosen in determining the aquifer parameters. This method was chosen because it is built upon the most simplifying assumptions. Here, the aquifer properties were estimated from the pumping test by fitting mathematical models (type curves) to response data (water level changes) using a procedure called curve matching. In particular, the curve matching technique of computer software known as aquifer test was used in this analysis. The type curve for the discharging and recovery phase as well as the field data as part of results are shown in the appendix.

Results/Recommendations per location

1. Location 2: Girim- Burum: ADA-MUBI-SOUTH-2019-001

Borehole depth = 61.5 m
SWL = 1.55 m
Q = 13248 L
q = 0.46 l/s
After pumping for 480 mins @ 0.46 l/s, DD = 30m (i.e 52.7%)
Available DD = 56.95m
Safe yield at 75% DD = 0.65 l/s
Volume of water Collectible in 7 hours = 16380 litres
Phsio-Chemical Parameters;
TDS =0.33 ppt
EC = 0.59µs
Temperature =29.4^{o} C
PH = 7.4
Recommended installation depth ; 58.5m
Recommended Scheme : Hand Pump

2. Location 3: Nasarawo Girls PS: ADA-MUBI-SOUTH-2019-002

Borehole depth =66.24 m
SWL = 3.55 m
Q = 7776 L
q = 0.27 l/s
After pumping for 480 mins @ 0.27 l/s, DD = 30m (i.e 50.25%)
Safe yield at 75% DD = 0.40 l/s
Available DD = 59.69 m
Volume of water Collectible in 7 hours = 10080 litres
Phsio-Chemical Parameters;
TDS =0.38 ppt
EC = 0.72µs
Temperature =30.03^{o} C
PH =7.26
Recommended installation depth ; 63.24m
Recommended Scheme : Hand Pump

3. Location 7: Muva Market: ADA-MUBI-NORTH-2019-003

Borehole depth = 41.8 m
SWL =2.43 m
Q = 23040 L
q = 0.8 l/s
After pumping for 480 mins @ 0.8 l/s, DD = 31m (i.e 81.9%)
Safe yield at 75% DD = 0.73 l/s
Available DD = 37.87m
Volume of water Collectible in 7 hours = 18396 litres
Phsio-Chemical Parameters;
TDS = 0.4 ppt
EC = 0.6µs
Temperature = 30.4^{o}C
PH = 7.26
Recommended installation depth ; 40.3m
Recommended Scheme : Solar Pump.

4. Location1 6: Duga: ADA-MUBI NORTH-2019-004

Borehole depth =64.1 m
SWL = 0.87m
Q = 12384 L
q = 0.43 l/s
After pumping for 480 mins @ 0.43 l/s, DD = 37m (i.e 61.4%)
Safe yield at 75% DD = 0.52 l/s

Available DD = 60.23m
Volume of water Collectible in 7 hours = 13104 litres
Phsio-Chemical Parameters;
TDS = 0.22 ppt
EC = 0.41µs
Temperature = 27.7^{o}C
PH = 7.14
Recommended installation depth ; 61.5m
Recommended Scheme : Solar Pump

5. Location 12: MaihaNguli: ADA-MAIHA-2019-005
Borehole depth = 25.25 m
SWL = 0.52 m
Q = 30240 L
q = 1.05 l/s
After pumping for 480 mins @ 1.05 l/s, DD = 16.5m (i.e 70.3%)
Safe yield at 75% DD = 1.12 l/s
Available DD = 23.48m
Volume of water Collectible in 7 hours = 28224 litres
Phsio-Chemical Parameters;
TDS =0.21 ppt
EC = 0.37µs
Temperature = 29.6^{o}C
PH =7.03
Recommended installation depth ; 24m
Recommended Scheme : Solar Pump

6. Location 14: MaihaHolmare: ADA-MAIHA-2019-006
Borehole depth =26.93 m
SWL =2.06 m
Q = 15552 L
q = 0.54 l/s
After pumping for 480 mins @ 0.54 l/s, DD = 23m (i.e 97%)
Safe yield at 75% DD = 0.42 l/s
Available DD = 23.37m
Volume of water Collectible in 7 hours = 10584 litres
Phsio-Chemical Parameters;
TDS = 0.26 ppt
EC = 0.47µs
Temperature = 30.4^{o}C
PH = 7.33
Recommended installation depth; 25.43m
Recommended Scheme : Hand Pump

III. Discussion of results

The six Boreholes drilled in these area ranges in depth from 25 m to 67m, with the discharge rate between 0.27 lit/sec to 1.05 lit/sec. The boreholes have static water levels between 0.52-3.55m. The result obtained from the measurement of physiochemical parameter on the field which is referred to as in-situe measurement. For electrical conductivity (EC) ranges between 0.37 - 0.72µs, PH between 7.03-7.4, Temperature (^{o}C) between 29.4 – 30.04 ^{o}C and for the total dissolved solids (TDS) is between 0.21 to 0.40 ppt. The depths between 25m to 67m which was drilled based on the recommendation from Geophysical survey provided water for the purpose it was drilled. The discharge rate of these bore hole were used as a guide to select the the type of pump to be installed i.e Hand pump and Solar Powered pump. As it is earlier stated the pumping test is carried out to evaluate aquifer performance and indeed to determine the installation depth of a borehole to obtain the maximum productivity. In this regard recommendations ofinstallation depths becomes necessary. Finally of the six Borehole drilled all were installed and are currently productive.

IV. Conclusion

The wells has good yield fitted with with hand Pump and Solar powered pump, with pumps installed at the depth of 24m,25.43m, 40.3m, 58.5m, 61.5m, and 63.2m. This depths is typical of of basement terrain where the aquifer lies between overburden/weathered basement and fractured basement.

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APPENDIX

PROJECT:		**DATE**: 14.09.2019	
LOCATION: GIRIMBULUM		**SWL:** 1.55m	
BH: NO.: ADA-MB- ST-2019-001		**PUMP TYPE**: 1HP	
BH. DEPTH: 61.5m		**PUMP RATE:** 0.461/s	
INSTALLATION DEPTH: 50m		**OBSERVER:**	

PUMP PHASE				**RECOVERY PHHASE**				
ELAPED TIME (mins)	***PUMPING W/L (m)***	***DRAW DOWN (m)***	***PUMPING RATE (l/s***	***TIME SINCE PUMPING (mins)***	***TIME SINCE RECOVERY (mins)***	***WATER LEVEL (m)***	***DRAW DOWN (m)***	***REMARKS***
0	1.55	0	0.26	480	0	31.55	30	
1	2.45	0.9	"	481	1	31.15	29.6	
2	3.2	1.65	"	482	2	30.55	29	
3	4.88	3.33	"	483	3	30.35	28.8	
4	5.48	3.93	"	484	4	29.55	28	
5	6.02	4.45	"	485	5	29.35	27.8	
6	6.49	4.94	"	486	6	28.65	27.1	
7	6.89	5.34	"	487	7	28.55	27	
8	7.3	5.75	"	488	8	28.35	26.6	
9	7.66	6.11	"	489	9	28.05	26.5	
10	7.98	6.43	"	490	10	27.55	26	

12	8.59	7.04	"	492	12	26.55	25	
14	9.13	7.58	"	494	14	25.75	24.2	
16	9.63	8.08	"	496	16	24.85	23.3	
18	10.54	8.99	"	498	18	24.55	23	
20	11.39	9.84	"	500	20	24.05	22.5	
25	13.13	11.58	"	505	25	22.3	20.75	
30	14.49	12.94	"	510	30	20.55	19	
35	15.6	14.05	"	515	35	18.65	17.1	
40	16.55	15	"	520	40	16.75	15.2	
45	17.5	15.95	"	525	45	15.3	13.75	
50	19	17.45	"	530	50	13.85	12.3	
55	19.69	18.14	"	535	55	12.6	11.05	
60	20.21	18.66	"	540	60	11.35	9.8	
70	21.65	20.1	"		70			
80	22.95	21.4	"		80			
90	23.95	22.4	"		90			
100	24.95	23.4	"		100			
130	27.15	25.6	"		130			
160	28.65	27.1	"		160			
180	29.55	28	"		180			
210	30.55	29	"		210			
240	31.05	29.5	"		240			
300	31.25	29.7	"		300			
360	31.35	29.8	"		360			
420	30.45	28.9	"		420			
480	31.55	30	"		480			

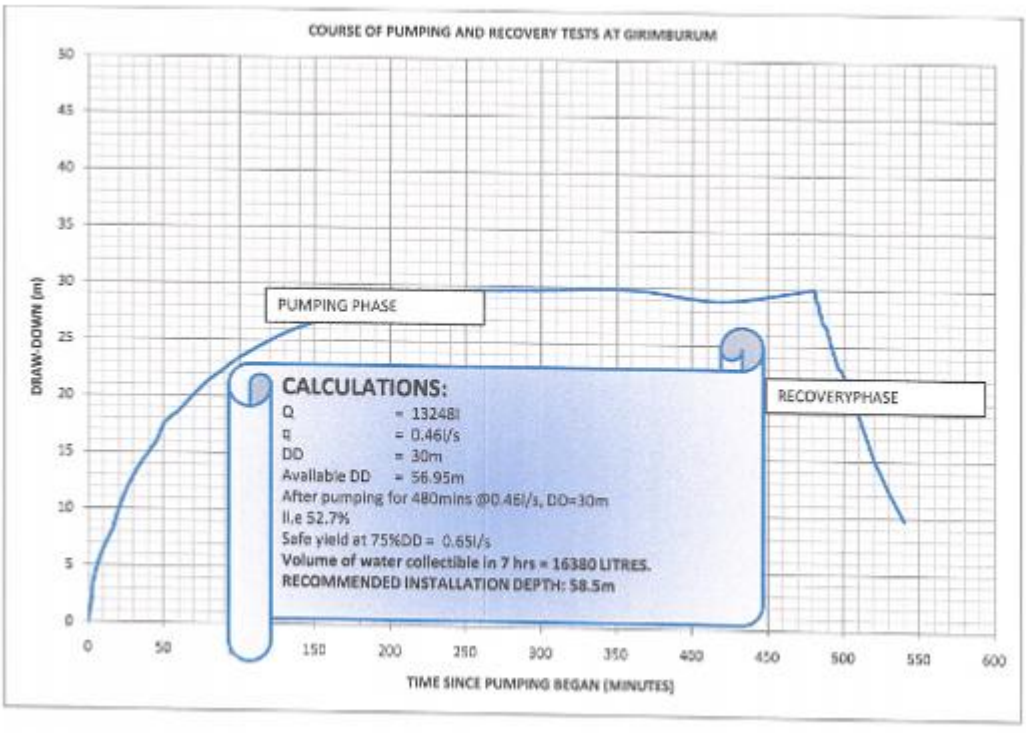

Fig. 2: Pumping and recovery curve for the recharging well

LOCATION: NASSARAWO GIRLS PS					**SWL:** 3.55m			
BH: NO.: ADA-MB-ST-2019-002					**PUMP TYPE**: 1HP			
BH. DEPTH: 66.24m					**PUMP RAT**E: 0.271/s			
INSTALLATION DEPTH: 50m					**OBSERVER.**			
PUMP PHASE				**RECOVERY PHHASE**				
ELAPED TIME (mins)	*PUMPING W/L (m)*	*DRAW DOWN (m)*	*PUMPING RATE (l/s*	***TIME SINCE PUMPING (mins)***	***TIME SINCE RECOVERY (mins)***	***WATER LEVEL (m)***	***DRAW DOWN (m)***	***REMARKS***
0	35.55	0	0.27	480	0	33.55	30	
1	5.03	1.48	"	481	1	32.95	29.4	
2	6.5	2.95	"	482	2	32.32	28.77	
3	6.95	3.4	"	483	3	32.3	28.75	
4	6.74	3.19	"	484	4	32.27	28.72	
5	7.3	3.75	"	485	5	32.25	28.7	
6	7.72	4.17	"	486	6	31.76	28.21	
7	8.15	4.6	"	487	7	31.27	27.72	
8	8.77	5.22	"	488	8	31.03	27.48	
9	8.77	5.22	"	489	9	30.99	27.44	
10	8.96	5.43	"	490	10	30.95	27.4	
12	9.21	5.66	"	492	12	30.4	26.9	
14	9.88	5.33	"	494	14	29.84	25.87	
16	10.69	7.14	"	496	16	29.42	27.48	
18	11.2	7.65	"	498	18	29.03	25.48	
20	11.94	8.39	"	500	20	28.55	25	
25	12.15	8.16	"	505	25	27.55	24	
30	12.65	9.1	"	510	30	26.15	22.6	
35	13.4	9.85	"	515	35	25.6	22.05	
40	14.15	10.6	"	520	40	25.05	21.5	
45	14.85	11.3	"	525	45	24.3	20.75	
50	15.55	12	"	530	50	23.5	20	
55	16.05	12.5	"	535	55	22.65	19.1	
60	16.55	13	"	540	60	21.75	18.2	
70	17.55	14	"		70			
80	18.55	15	"		80			
90	19.55	16	"		90			
100	20.45	16.9	"		100			
130	21.45	17.9	"		130			
160	24.05	20.5	"		160			
180	25.35	21.8	"		180			
210	26.55	23	"		210			
240	27.65	24.1	"		240			
300	29.95	26.4	"		300			
360	31.55	28	"		360			
420	32.85	29.3	"		420			
480	33.55	30	"		480			

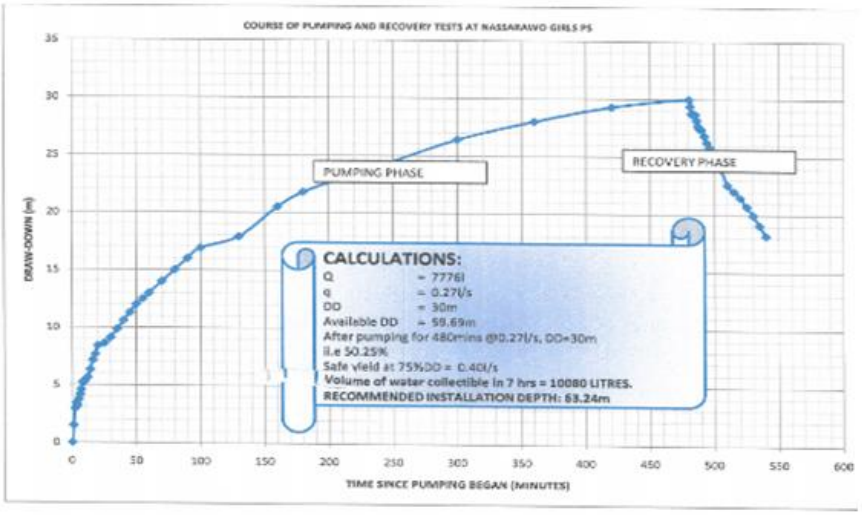

Fig. 3: Pumping and recovery curve for the recharging well

LOCATION: MUVA MARKET		**SWL:** 2.43m	
BH: NO.: ADA-MUB-N-2019-003		**PUMP TYPE**: 1HP	
BH. DEPTH: 41.8m		**PUMP RAT**E: 0.81/s	
INSTALLATION DEPTH: 40m		**OBSERVER**	

PUMP PHASE				**RECOVERY PHHASE**				
ELAPED TIME (mins)	***PUMPING W/L (m)***	***DRAW DOWN (m)***	***PUMPING RATE (l/s***	***TIME SINCE PUMPING (mins)***	***TIME SINCE RECOVERY (mins)***	***WATER LEVEL (m)***	***DRAW DOWN (m)***	***REMARKS***
0	22.43	0	0.8	480	0	33.43	31	
1	2.62	0.22	"	481	1	32.83	30.4	
2	3.09	0.66	"	482	2	32.83	29.8	
3	4.3	1.87	"	483	3	31.43	29	
4	4.5	2.07	"	484	4	31.03	28.6	
5	4.8	2.37	"	485	5	30.43	28	
6	5.22	2.79	"	486	6	29.73	27.3	
7	5.42	2.99	"	487	7	29.23	26.8	
8	5.96	3.55	"	488	8	28.53	26.1	
9	6.4	3.97	"	489	9	28.23	25.8	
10	6.7	4.27	"	490	10	27.43	25	
12	7.03	4.6	"	492	12	26.43	24	
14	7.21	4.78	"	494	14	26.03	23.6	
16	8	5.57	"	496	16	25.03	22.6	
18	8.5	6.07	"	498	18	24.23	21.8	
20	8.85	6.43	"	500	20	23.43	21	
25	9.13	6.7	"	505	25	21.43	19	
30	11.75	9.32	"	510	30	19.43	17	
35	12.53	10.1	"	515	35	18.33	15.9	
40	13.43	11	"	520	40	17.23	14.8	
45	14.33	11.9	"	525	45	15.08	12.65	
50	15.23	12.8	"	530	50	12.93	10.5	
55	16.03	13.6	"	535	55	11.68	9.25	
60	16.83	14.4	"	540	60	10.43	0	
70	18.43	16	"		70			
80	19.43	17	"		80			
90	20.73	18.3	"		90			
100	21.63	19.2	"		100			
130	24.33	21.9	"		130			
160	26.53	24.1	"		160			
180	27.63	25.2	"		180			

210	29.43	27	"		210			
240	30.43	28	"		240			
300	32.43	30	"		300			
360	32.93	30.5	"		360			
420	33.23	30.8	"		420			
480	33.43	31	"		480			

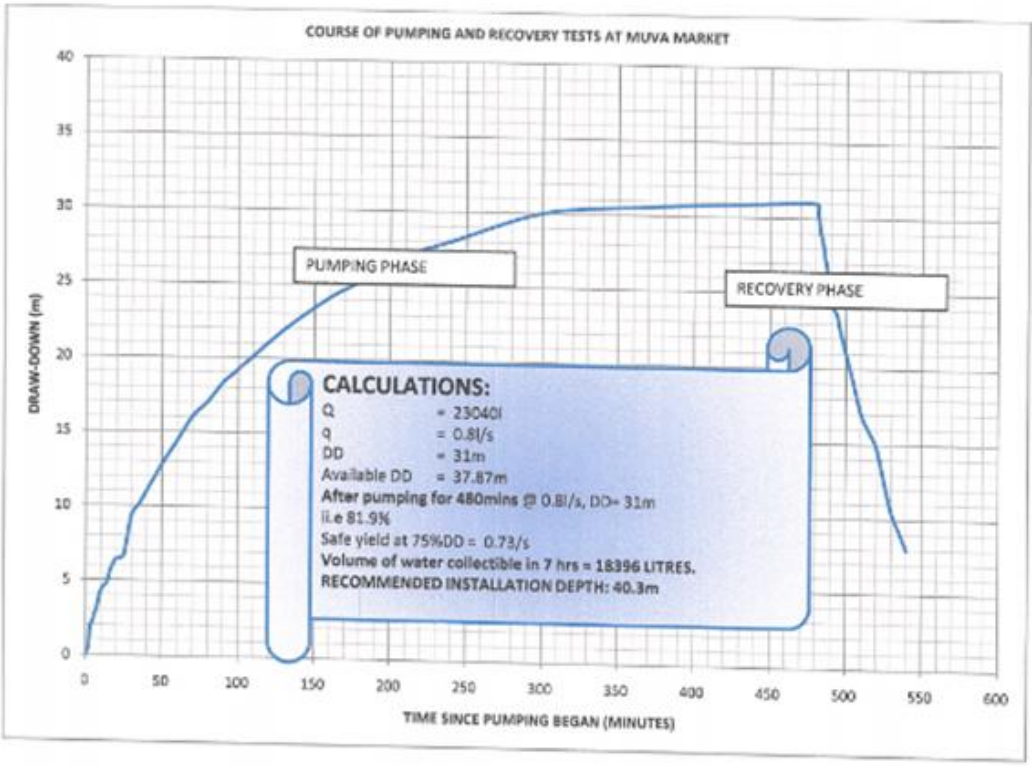

Fig. 4: Pumping and recovery curve for the recharging well

LOCATION: DUGA			**SWL:** 0.87m
BH: NO.: ADA-MUB-N-2019-004			**PUMP TYPE**: 1HP
BH. DEPTH: 64.10m			**PUMP RAT**E: 0.431/s
INSTALLATION DEPTH: 50m			**OBSERVER**

PUMP PHASE				**RECOVERY PHHASE**				
ELAPED TIME (mins)	***PUMPING W/L (m)***	***DRAW DOWN (m)***	***PUMPING RATE (l/s***	***TIME SINCE PUMPING (mins)***	***TIME SINCE RECOVERY (mins)***	***WATER LEVEL (m)***	***DRAW DOWN (m)***	***REMARKS***
0	0.87	0	0.43	480	0	37.87	37	
1	2.13	1.26	"	481	1	37.47	36.6	
2	2.28	1.41	"	482	2	36.87	36	
3	2.56	1.69	"	483	3	36.37	35.5	
4	2.9	2.03	"	484	4	35.87	35	

5	23.27	2.4	"	485	5	35.37	34.5	
6	3.59	2.72	"	486	6	34.87	34	
7	3.76	2.89	"	487	7	34.67	33.8	
8	3.93	3.06	"	488	8	34.27	33.4	
9	4.2	3.33	"	489	9	33.87	33	
10	4.47	3.6	"	490	10	33.37	32.5	
12	5.2	4.33	"	492	12	32.87	32	
14	6.34	5.47	"	494	14	31.87	31	
16	7.7	6.83	"	496	16	30.87	30	
18	9.1	8.23	"	498	18	29.87	29	
20	11.5	10.63	"	500	20	28.87	28	
25	11.17	10.3	"	505	25	27.12	26.25	
30	11.87	11	"	510	30	25.37	24.5	
35	13.37	12.5	"	515	35	23.87	23	
40	14.87	14	"	520	40	22.37	21.5	
45	16.02	15.15	"	525	45	21.12	20.25	
50	17.17	16.3	"	530	50	19.87	19	
55	18.02	17.15	"	535	55	18.37	17.5	
60	18.87	18	"	540	60	16.87	16	
70	20.87	20	"		70			
80	22.27	21.4	"		80			
90	23.87	23	"		90			
100	25.87	25	"		100			
130	29.67	28.8	"		130			
160	32.07	31.2	"		160			
180	33.67	32.8	"		180			
210	34.87	34	"		210			
240	35.87	35	"		240			
300	37.38	36.5	"		300			
360	37.87	37	"		360			
420	37.87	37	"		420			
480	37.87	37	"		480			

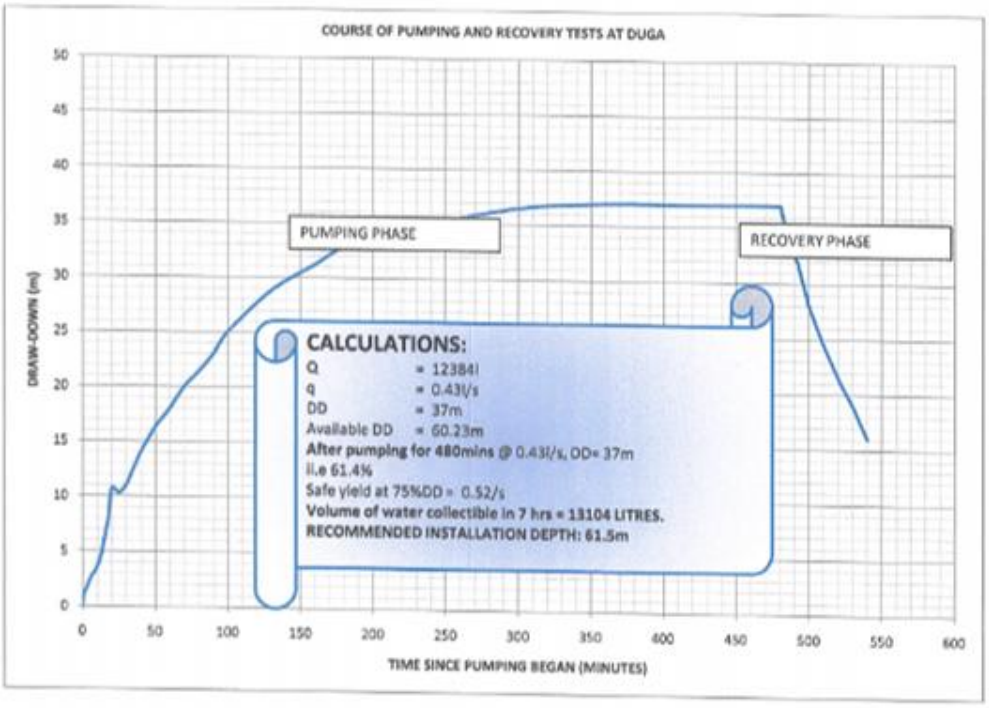

Fig. 5: Pumping and recovery curve for the recharging well

LOCATION: MAIHA HOLMARE		**SWL:** 2.06
BH: NO.: ADA-MAIHA-2019-005		**PUMP TYPE**: 1HP
BH. DEPTH: 26.93m		**PUMP RAT**E: 0.541/s
INSTALLATION DEPTH: 25m		**OBSERVER**

PUMP PHASE				**RECOVERY PHHASE**				
ELAPED TIME (mins)	***PUMPING W/L (m)***	***DRAW DOWN (m)***	***PUMPING RATE (l/s***	***TIME SINCE PUMPING (mins)***	***TIME SINCE RECOVERY (mins)***	***WATER LEVEL (m)***	***DRAW DOWN (m)***	***REMARKS***
0	2.06	0	0.54	480	0	25.06	23	
1	3.11	1.05	0.54	481	1	24.06	22	
2	3.25	1.19	"	482	2	23.56	21.5	
3	3.45	1.39	"	483	3	23.06	21	
4	3.8	1.74	"	484	4	22.86	20.8	
5	4.37	2.31	"	485	5	22.66	20.6	
6	4.7	2.64	"	486	6	22.46	20.4	
7	4.93.	2.87	"	487	7	22.06	20	
8	5.08	3.02	"	488	8	21.06	19	
9	5.18	3.12	"	489	9	20.56	18.5	
10	5.27	3.21	"	490	10	20.06	18	
12	5.4	3.34	"	492	12	19.06	17	
14	5.48	3.42	"	494	14	17.56	15.5	

16	5.495	3.435	"	496	16	16.66	14.6	
18	5.7	3.64	"	498	18	14.86	12.8	
20	7.06	5	"	500	20	14.56	12.5	
25	8.06	6	"	505	25	12.81	19,75	
30	9.06	7	"	510	30	11.06	9	
35	9.66	7.6	"	515	35	9.06	7	
40	10.26	8.2	"	520	40	7.06	5	
45	10.81	8.75	"	525	45	5.56	3.5	
50	11.36	9.3	"	530	50	4.06	2	
55	12.16	10.1	"	535	55	3.06	1	
60	12.96	10.9	"	540	60	2.06	0	
70	13.56	11.5	"		70			
80	14.86	12.8	"		80			
90	15.86	13.8	"		90			
100	16.26	14.2	"		100			
130	18.06	16	"		130			
160	18.96	16.9	"		160			
180	20.86	18.8	"		180			
210	21.86	19.8	"		210			
240	22.96	20.9	"		240			
300	23.36	21.3	"		300			
360	24.06	22	"		360			
420	24.56	22.5	"		420			
480	25.06	23	"		480			

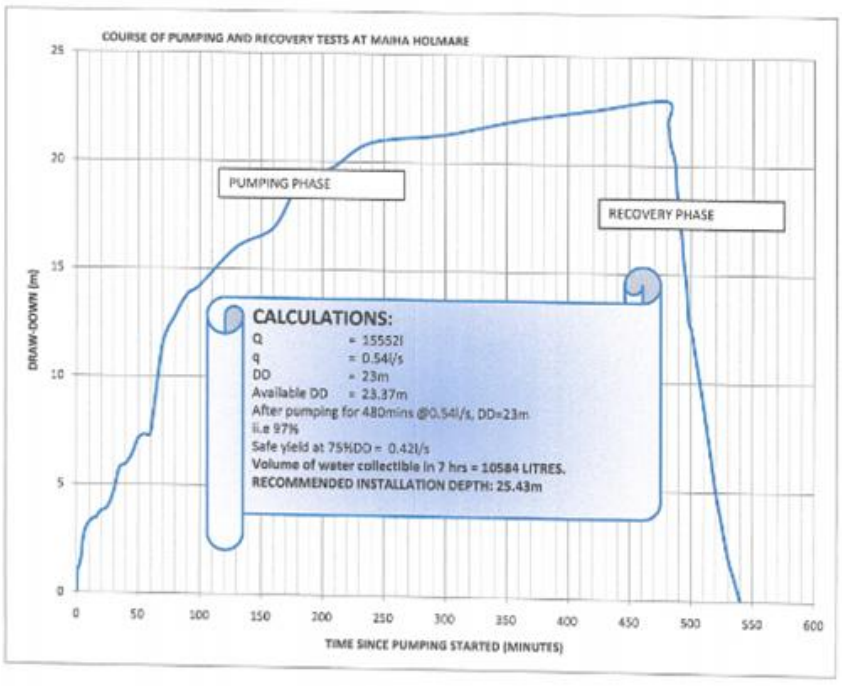

Fig. 6: Pumping and recovery curve for the recharging well

LOCATION: MAIHA NGULI		**SWL:** 0.52m	
BH: NO.: ADA-GIZ-2019-015		**PUMP TYPE**: 1HP	
BH. DEPTH: 25.25m		**PUMP RAT**E: 1.051/s	
INSTALLATION DEPTH: 22.5m		**OBSERVER**	

PUMP PHASE				**RECOVERY PHHASE**				
ELAPED TIME (mins)	***PUMPING W/L (m)***	***DRAW DOWN (m)***	***PUMPING RATE (l/s***	***TIME SINCE PUMPING (mins)***	***TIME SINCE RECOVERY (mins)***	***WATER LEVEL (m)***	***DRAW DOWN (m)***	***REMARKS***
0	0.52	0	1.05	480	0	17.02	16.5	
1	0.82	0.3		481	1	15.02	14.5	
2	1.02	0.5	"	482	2	13.52	13	
3	1.22	0.7	"	483	3	12.12	11.6	
4	1.37	0.85	"	484	4	10.92	10.4	
5	1.52	1	"	485	5	9.62	9.1	
6	1.62	1.1	"	486	6	8.52	8	
7	1.72	1.2	"	487	7	7.52	7	
8	1.74	1.22	"	488	8	7.02	6.5	
9	1.77	1.25	"	489	9	6.32	5.8	
10	1.82	1.3	"	490	10	5.52	5	
12	2.16	1.64	"	492	12	3.82	3.3	
14	2.5	1.98	"	494	14	2.52	2	
16	2.84	2.32	"	496	16	1.52	1	
18	3.18	2.66	"	498	18	0.72	0.2	
20	3.52	3	"	500	20	0.52	0	
25	4.02	3.5	"	505	25	0.52	0	
30	4.52	4	"	510	30	0.52	0	
35	5.02	4.5	"	515	35		0	
40	5.52	5	"	520	40			
45	6.02	5.5	"	525	45			
50	6.52	6	"	530	50			
55	6.87	6.35	"	535	55			
60	7.22	6.7	"	540	60			
70	8.12	7.6	"		70			
80	8.72	8.2	"		80			
90	9.52	9	"		90			
100	10.22	9.7	"		100			
130	11.52	11	"		130			
160	12.52	12	"		160			
180	13.32	12.8	"		180			

210	14.32	13.8	"		210			
240	15.02	14.5	"		240			
300	15.82	15.3	"		300			
360	16.82	16.3	"		360			
420	17.02	16.5	"		420			
480	17.02	16.5	"		480			

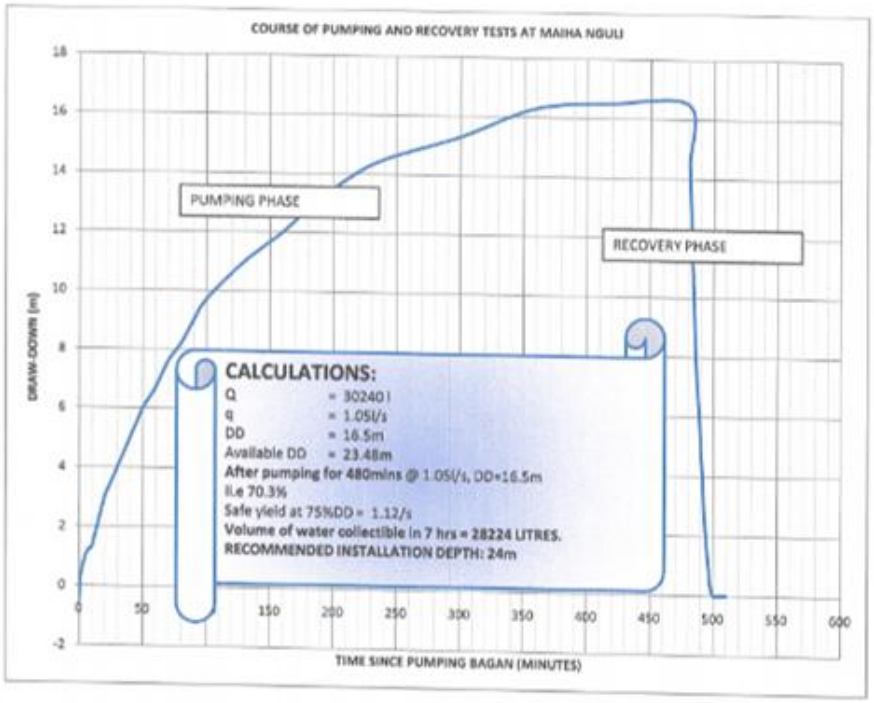

Fig. 7: Pumping and recovery curve for the recharging well

KASIDI S.. "Evaluation of Aquifer Performance Using A Pumping Test of Boreholes Drilled In Different Part Of Mubi And Environs, North-Estern, Nigeria."*IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)*, 8(3), (2020): pp 48-61.