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PUMPING TEST DATA ANALYSIS FOR LEMAKENYA LTD – ARCHERS POST BH

Tabulated below is a summary of datum data obtained for this particular facility.

Pump type	**Grundfos SP 5A-44**
Type of pumping test	Controlled Rate Test (CRT)
Reference datum for water level measurement	Ground level
Duration of pumping test	24.0 hrs
Duration of recovery	80Mins
Borehole depth	m
Pump setting depth	96.0m
Static water level (SWL), (m)	4.3m
Draw down	55.9m
Borehole yield	5.2 m^3/hr

EXECUTIVE SUMMARY

Test pumping exercise is an essential practical method of analyzing the borehole performance in terms of borehole yield and borehole's zone of influence. In addition, the aquifer characteristics such as aquifer extent and its ability to transmit and store water can also be evaluated reliably from the test pumping exercise program.

Test pumping was conducted on 9th April 2025. A constant discharge test was performed for 24 hours at intervals indicated on the appended test pumping data sheet. A sonic water level indicator was utilized to take the water depth measurements. The static water level (SWL) in the borehole was 4.3 m below the reference datum at the start of the constant discharge test. Recovery test was monitored on 10th April 2025 for duration of 80 minutes. The tests intervals for the recovery are also indicated on the recovery chart also appended.

From the obtained data, the drawdown verses time function and recovery series verses time function has been plotted. Using the Cooper-Jacob method, the drawdown and recovery data were analyzed giving Transmissivity (T) of 0.762 m^2/day and 0.531 m^2/day for draw-down and

residual tests respectively.

Test pumping programs are essential and practical methods of analyzing the borehole performance in terms of borehole yields.

1.0 THE BASELINE PRINCIPAL FOR THE TEST PUMPING DATA

Pumping test gives the best information on the drawdown level, flow rates and unforeseen factors generated upon pumping. The principle of a pumping test involves applying a stress to an aquifer by extracting ground water from a pumping well and measuring the aquifer response to that stress by monitoring drawdown as a function of time. The measurements are then incorporated into an appropriate well-flow equation to calculate the hydraulic parameters of the aquifer.

After the pump has been shut down, the water level in the well start to rise again. These rises are measured in what is known as recovery test. **If pumping rate was not constant throughout the pumping test, the recovery- test data are more reliable than draw down data because the water table recovers at a constant rate.**

1.1 OBJECTIVES

The prime objective for which the test pumping exercise is conducted involves the aim to regulate and optimize the extraction of water from the borehole without adversely impacting the aquifer systems.

The specific objectives for the test pumping are:

- ✔ To determine how much ground water can be extracted from a well based on the long-term yield and the well efficiency.
- ✔ To determine the hydraulic properties of the aquifer namely; Transmissivity, Specific capacity and Yield.
- ✔ To evaluate the spatial effects of pumping on the aquifer
- ✔ To determine and ascertain the suitable depth of pumping
- ✔ To assess the information on water quality and its variability with time.

1.2 STATEMENT OF SCOPE

Pumping tests was typically done to determine well performance in line to ensuring selection of the correct pumping equipment. The data from the pumping tests is used to calculate the specific capacity (*Q/s* where *Q* = yield and *s* = drawdown) of the well. In addition, the aquifer transmissivity is also determined, as well as the flow projections based on the computed values of specific capacity and transmissivity T. Further, the borehole pumping requirements are determined for the purposes of pumping specifications design optimization.

3.0 TEST PUMPING METHODOLOGY AND ANALYSIS

The test-pumping exercise was carried on the 9th April 2025 for a duration of 24 hours and an additional 80 minutes for the recovery measurement. The borehole calibration test was done at a controlled Rate of discharge which was 5.2m^3/hr. This is an averaged value for the entire test period. It is vital to make note of the fact that the discharge output consequently resulted to a draw -down value of 55.9 m to the penultimate depth of 60.2 m below ground level.

A general technical contention that can henceforth be drawn from the test data is that, with the threshold aquifer estimate of 5.2 m^3/hr, it is unlikely for the aquifer to be stressed to a critical level and it is hence sustainable. This would imply that there would be no limitation to both abstraction and sustainability from the aquifer.

The ultimate design for this aquifer at the limit of 5.2 m^3 /hr on the basis of performance efficiency schedules cannot be considered a gross over-estimation of the aquifer potential.

From a Static Water Level – 4.3m below ground level, and a startup output of 7.5m^3/hr., the water level slowly draws down the level to the maximum recorded draw-down level of 60.2m.

Recommended Discharge

Important to note: The decisive recommended discharge of 5.2m^3/hr., is ideal. The facility will thus support design discharge within this range safely ensuring the reduction of the developing stress to the aquifer system hence guaranteeing the facility's sustainability.

4.0 DATA, RESULTS AND ANALYSIS

The analysis of test results data was done by use of the Cooper-Jacob- time- drawdown method. This method is an approximation to Theis method in which a graphical plot of the test data was plotted using a semi-log plot of the field drawdown data, on a linear scale, versus time, normal log scale. A straight line was then drawn through the field-data points. The value of the drawdown per log cycle of time, ΔS, was obtained from the slope of the graph. The value of transmissivity was then calculated from the following equation:

$$T = \frac{2.3Q}{2\pi\Delta S}$$

Where Q is the pumping rate

ΔS represent the linear plot gradients.

4.1 AQUIFER PARAMETERS

4.1.1 TRANSMISSIVITY OF THE AQUIFER

Owing to the moderate draw-down observed for the aquifer, the transmissivity of the ground water is moderate to high. This type of yield is associated with the fractured zone and sediments making up the aquifer at this area. The moderate draw-downs suggest a high deployable yield potential than that recorded by the Test – Pumping exercise program.

There is a support inference that can be inferred from the test data. The type data is associated with a regional fracture system to support such flow. In such a scenario, the value of T associated with the system will occur defined along the fracture lineament to permit very high discharge outputs and the possibility of pumping the levels to deeper sections of the aquifer.

However, these values can be slightly skewed in particular reference to this aquifer as it cannot be accurately computed within the context of the 55.9 m drawdown and the subsequent recovery trend.

The type of Transmissivity that can be ascribed to this aquifer can only be accurately determined in the event of higher discharge from the facility to adequately stress the aquifer. The fact that it is ascribed to the 55.9 m drawdown induced in the facility is indicative of its inherent inaccuracy.

From the rule of thumb estimate, a sustained pumping capacity to the flow of 5.2m^3/hr would not have a strain to the aquifer efficiency.

AQUIFER TRANSMISSIVITY

Obtained Transmissivity values were as follows.

Draw-down test	**0.762 m2/day**	
Residuals	**0.531 m2/day**	*These values favor the scenario for medium flow out-puts at the reduced pumping heads.*
Average T	**0.647 m2/day**	

The T values for both Draw-down and residual recovery are moderately high. For this particular facility, the T value from the recovery test can be taken to be more accurate owing to the fact that the water level in aquifer resumes at a constant rate. However, an average of the two values of T has been determined and can be used for purposes of further calculation of parameters since it's deviation from the two computed values is slightly marginal.

The computed T value can be considered to be grossly equitable to the threshold estimate from the aquifer of 5.2m^3/hr. The hydraulic efficiency of the system can also be inferred to be quite high to support the suggested discharge recommended.

The high operational efficiency of this system would conform to a scenario where the borehole can be pumped to its maximum rated capacity – though constrained to 5.2m^3/hr to avoid the event of over- abstraction from the aquifer series.

4.1.2 SPECIFIC CAPACITY

The borehole's specific capacity was also determined

$$Q/\Delta S = \frac{5200}{3600(\text{sec/Hr.}) * 55.9} = 0.026 m^2/day$$

Commentary:

The specific capacity is adequate for a moderate flow- water supply borehole. This value of the specific capacity is an indicator of the moderate yield potential associated with this aquifer. Nevertheless, the specific capacity obtained for this particular aquifer is not necessarily accurate, and is more of a casing storage component.

4.1.3 Flow Design Mode

Assuming the cumulative draw-down in the borehole is enhanced by 30m, it achieves a pumped water level maximum of 90.2m below ground level. This is a viable assumption, in the sense there is still a reserve column for the pump submergence and design purposes - in the form of potential draw-down in the pumping facility.

The rule of thumb and the specific capacity would ultimately indicate a variable discharge output, illustrated by the Darcy's relation;

$$Enhanced\ Discharge = {}^{Q}/_{\Delta S(ddn)}$$

Knowing that specific capacity is 0.026m2/day, it follows therefore that with an additional draw-down of 30.0m, discharge (Q) becomes;

Q = 0.026 x 85.9x3600/1000 = 7.99m^3/hr.

The safe yield for abstraction should be 70% of total yield. Thus becomes 5.6 m^3/hr.

Q = 5.6 m^3/hr at a pumping water 90.2 m below ground level.

Nonetheless, this discharge is liable to induce increased levels of stress to the aquifer. Over-

pumping of the facility is likely to cause the following adverse system effects: -

- Exposure of the first screened areas to air damp.
- Loss of pore space within the upper sediment aquifers.
- Deterioration of discharge over short pumping regimes due to encrustation developmer in screen areas.
- Lowered overall - performance efficiency of the system.

Taking into consideration other head losses, the total operating head of the pumping equipmer will be estimated by the following:

- Frictional head loss - 5m
- Fittings losses - 5m
- Elevation head - 10m

Total Head H, = 90.2+5+5+10

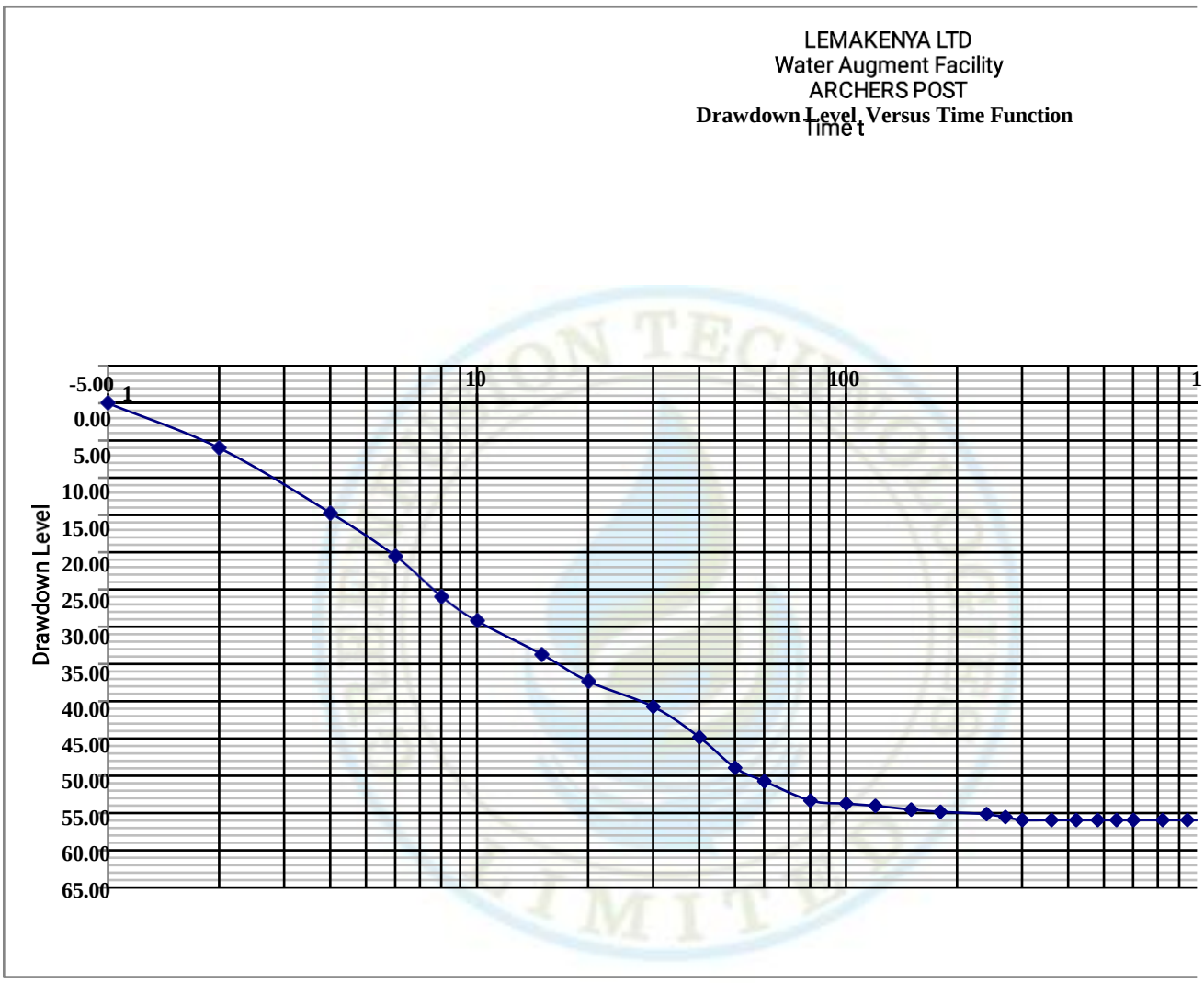
H = 110.2m

Therefore, Optimized Duty Point

Q =5.6 m^3/hr at a pumping water head of 110.2m below ground level.

4.1.4 OPTIMIZED PUMP SET.

Pump make	Pump model	Rated HSP	Installation Depth.
DAYLIFF	DS 5 -33	3.0Kw[4.0Hp]	96m. The optimum down-hole pipe-work for this borehole is 1.5" GI. The frictional head loss for the system within a 1.5" down-hole pipe-work will be Negligible.


LEMAKENYA LTD
Water Augment Facility
ARCHERS POST
Drawdown Level Versus Time Function
Time t
Drawdown Level
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
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55.00
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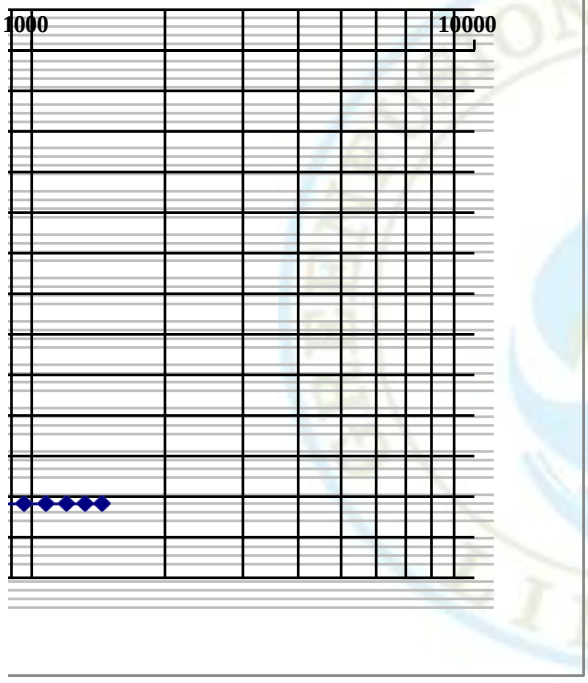
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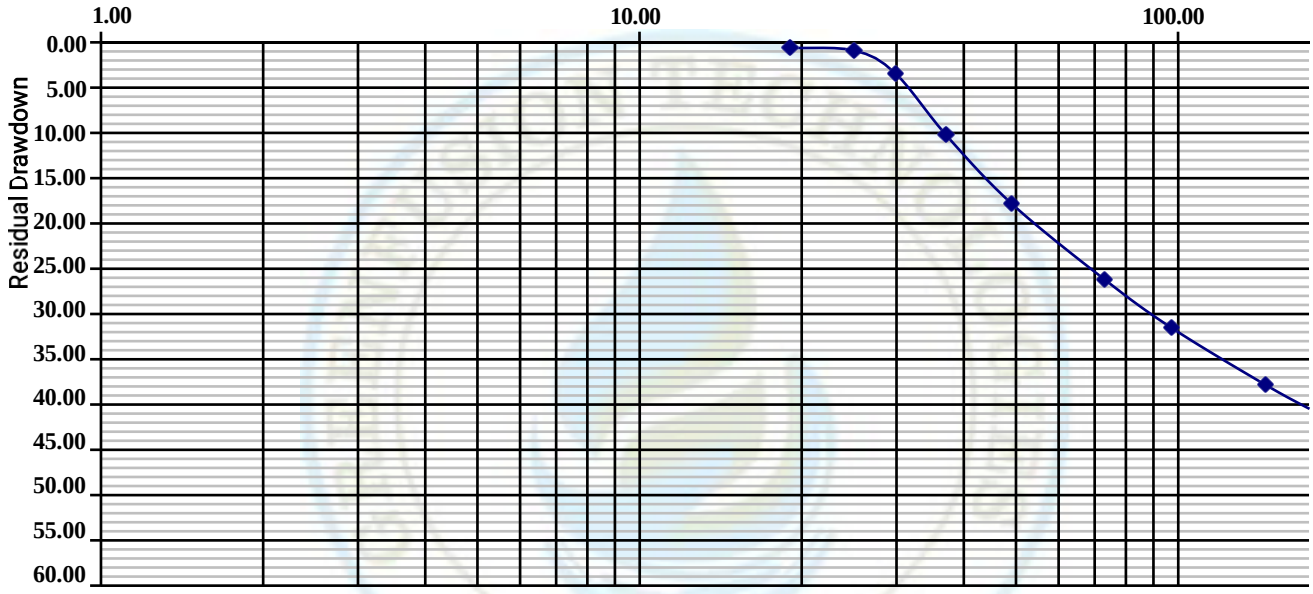
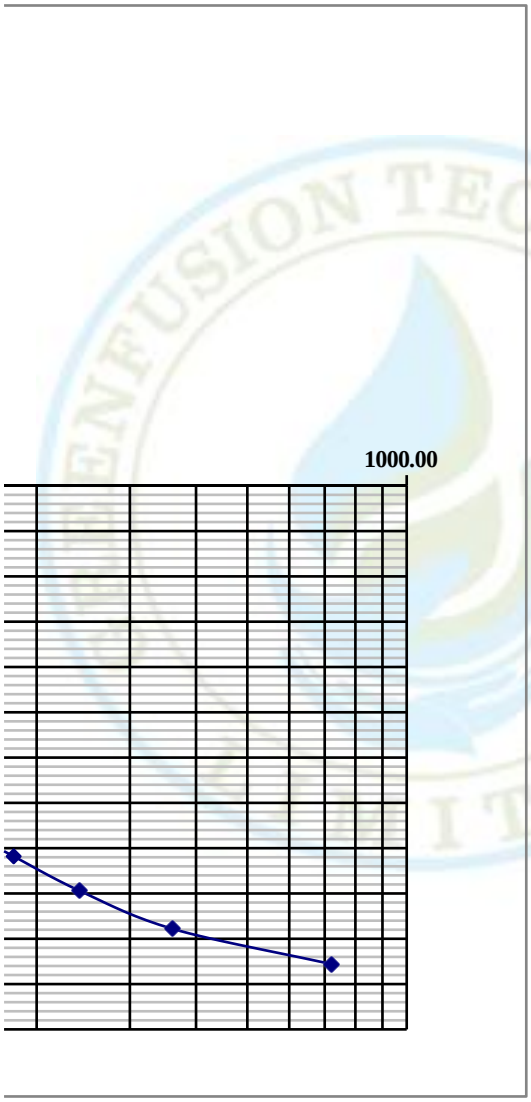
TEST PUMPING - DRAWDOWN MEASUREMENTS

Client Name: LEMAKENYA LTD
Borehole Name: ARCHERS POST
Borehole Depth : m
SWL: 4.30 m
Discharge During Test: 5.2m³/hr
Water Sample taken: Yes
Pump Intake Depth: 96m
Pumping Water Level: 60.20m
Pump Type: Grundfos SP 5A-44
Date of Test: 09/04/2025

CLOCK TIME	METER READING	ELAP TIME Min:	WATER LEVEL M, bgi (x)		DRAWDOWN	DISCHARGE	REMARKS	
		0	4.30	0	0.00	7.5m³/hr	G.V fully ope	n
		2	10.30	2	6.00			
		4	19.00	4	14.70			
		6	24.80	6	20.50		clear water	
		8	30.20	8	25.90			
		10	33.50	10	29.20	6.5m³/hr		
		15	38.00	15	33.70			
		20	41.60	20	37.30			
		30	45.00	30	40.70	6.0m³/hr	clear water	
		40	49.10	40	44.80			
		50	53.20	50	48.90			
		60	55.00	60	50.70	5.2m³/hr		
		80	57.60	80	53.30			
		100	58.00	100	53.70			
		120	58.30	120	54.00			
		150	58.80	150	54.50			
		180	59.10	180	54.80			
		240	59.40	240	55.10			
		270	59.80	270	55.50	5.2m³/hr		
		300	60.20	300	55.90			
		360	60.20	360	55.90			
		420	60.20	420	55.90		Clear water	
		480	60.20	480	55.90			
		540	60.20	540	55.90			
		600	60.20	600	55.90	5.2m³/hr		
		720	60.20	720	55.90			
		840	60.20	840	55.90			
		960	60.20	960	55.90			
		1080	60.20	1080	55.90			
		1200	60.20	1200	55.90			
		1320	60.20	1320	55.90			
		1440	60.20	1440	55.90	5.2m³/hr	Sampled	

LEMAKENYA LTD
WATER AUGMENT FACILITY
ARCHERS POST
Recovery Series Versus Time Function

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TEST PUMPING - RECOVERY MEASUREMENTS

Client Name: LEMAKENYA LTD Borehole Name: ARCHERS POST

Date: 10/04/2025

Day	Hour	TIME SINCE PUMP STOPPED Min t	Pumping ended t' (Min)	RATIO t'/t	Residual DDn in m	Water level in(metres)
		0	**1440**		**55.90**	**60.20**
		2	**1442**	**721.00**	**52.80**	**57.10**
		4	**1444**	**361.00**	**48.90**	**53.20**
		6	**1446**	**241.00**	**44.70**	**49.00**
		8	**1448**	**181.00**	**40.90**	**45.20**
		10	**1450**	**145.00**	**37.80**	**42.10**
		15	**1455**	**97.00**	**31.50**	**35.80**
		20	**1460**	**73.00**	**26.20**	**30.50**
		30	**1470**	**49.00**	**17.80**	**22.10**
		40	**1480**	**37.00**	**10.20**	**14.50**
		50	**1490**	**29.80**	**3.40**	**7.70**
		60	**1500**	**25.00**	**0.90**	**5.20**
		80	**1520**	**19.00**	**0.60**	**4.90**

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CERTIFICATE OF ANALYSIS

CLIENT DETAILS

SAMPLE ID NO:	QIL/07/16801/25	**CLIENT NAME:**	LAMAKENYA LIMITED COMPANY
SAMPLING LOCATION:	ISIOLO COUNTY	**CONTACT INFORMATION:**	**KELVIN LPESINA.**
SAMPLE DESCRIPTION:	RAW BOREHOLE WATER		**phone Number: 0710699789**
SAMPLE SOURCE:	ARCHERS POST SITE	**SAMPLED BY:**	CLIENT
DATE OF SAMPLING:	10.04.2025	**TEST LOCATION:**	PERMANENT MAIN FACILITY
DATE OF RECEIPT:	02.05.2025	**SAMPLING METHOD/ PLAN**	STRATIFIED
DATE OF ANALYSIS:	02.05.2025	**JOB REQUEST REF FORM:**	QILL/JRRF/1680
DATE OF COMPLETION:	03.05.2025	**TEST CERTIFICATE ID NUMBER:**	QILL0012428
STANDARDS INFORMATION:	KS EAS 12:2018 Specification for Potable Water (Table 7). Specifies requirements, sampling and test methods for potable water intended for direct human consumption, domestic and industrial use. Guidelines for drinking-water quality, WHO 4th Edition, incorporating the 1st addendum.		

LABORATORY TEST REPORT

PARAMETERS	TEST STANDARD	KS EAS 12:2018	WHO 4TH EDITION	RESULTS	REMARKS
PHYSICAL REQUIREMENTS					
Color, TCU[a] , max	ISO 7887	50	15	23	**Non-Compliant**
Turbidity, NTU, max	ISO 7027	25	5	08	**Non-Compliant**
pH	ISO 10523	5.5-9.5	6.5 – 8.5	7.68	Compliant
Conductivity, (µS/cm), max	ISO 7888	2500	1500	8120	**Non-Compliant**
Total Dissolved Solids, mg/l, max	ASTM D 5907	1500	1000	4060	**Non-Compliant**
Total Suspended Solids (TSS), mg/l	ISO 11923	00	00	09	**Non-Compliant**
Salinity ,mg/l	APHA 2520	NS	NS	4730	NS
CHEMICAL REQUIREMENTS					
Total Hardness, as $CaCO_3$, mg/l, max	APHA 2340	600	500	680	**Non-Compliant**
Total alkalinity, as PH 8.3	ISO 9963-1	NS	255	0.00	Compliant
Phenolphthalein alkalinity (HCO_3^2)	ISO 9963-1	NS	255	0.00	Compliant
Free Carbon Dioxide ,(CO_2), ppm	APHA 4500	NS	NS	52.80	NS
Sulphate, SO_4, mg/l, max	APHA 4500 – SO_4	400	400	578	**Non-Compliant**
Phosphates, as PO_4^b, mg/l, max	ISO 15681	2.2	NS	0.50	Compliant
Nitrate, as NO_3, mg/, max	ISO 7890	45	10	8.30	Compliant
Ammonia (NH_3), mg/l, max	ISO 11732	0.5	1.5	0.06	Compliant
Fluoride, as F, mg/l, max	APHA 4500 – F^-	1.5	1.5	2.01	**Non-Compliant**
Chloride, as Cl , mg/l, max	ISO 9297	250	NS	1829.43	**Non-Compliant**
Total Iron as Fe^{++}, mg/l, max	APHA 3500-Fe	0.3	0.3	0.08	Compliant
Sodium, as Na^+, mg/l, max	ISO 9964-1	200	200	731.77	**Non-Compliant**
Zinc, as Zn^{++}, mg/l, max	ISO 8288	5.0	3.0	0.38	Compliant
Aluminium as Al, mg/l, max	ISO 12020	0.2	0.2	0.04	Compliant
Magnesium, as Mg^{++}, mg/l, max	APHA 4500-Mg	100	100	98.99	Compliant
Calcium, as Ca^{++}, mg/l, max	APHA 4500-Ca	150	100	184.00	**Non-Compliant**
Manganese, as Mn, mg/l, max	ISO 6333	0.1	0.1	<0.01	Compliant

ABBREVIATIONS:
TCU – TRUE COLOR UNITS, NTU – NEPHELOMETRIC TRUE UNIT, NS – NO SET STANDARDS; ND –NOT DETECTED; ISO – INTERNATIONAL ORGANIZATION FOR STANDARDIZATION; KS – KENYA STANDARDS; KEBS – KENYA BUREAU OF STANDARDS; EAS – EAST AFRICAN STANDARDS; ASTM – AMERICAN STANDARDS TEST MATERIALS; APHA – AMERICAN PUBLIC HEALTH ASSOCIATION

OPINIONS AND INTERPRETATIONS.

The **ARCHERS POST SITE** Raw Borehole Water is **Non-Compliant** to the requirements of the natural potable drinking water due to high levels of **Color, Turbidity, Conductivity, TDS, TSS, Total Hardness, Sulphates, Fluorides, Chlorides, Sodium** and **Calcium** as per the KS EAS 12:2018 Specification for Potable Water and guidelines for drinking water quality of WHO 4th Edition. Thus, further treatment is advised.
This water can also be used for other purposes such as agricultural, irrigation, industrial cleaning and domestic uses.

The report was reviewed and approved by the authorized signatory below.

JEROME EMOO;

CHIEF EXECUTIVE OFFICER

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