

## 6-3 Borehole survey Reports (Extract)

The Project for Reconstruction and Expansion of Selected Community Day Secondary Schools and Conventional Secondary Schools (Phase III)  
in The Republic of Malawi

### Borehole Survey Report

#### 1. Test Drilling Results

##### 1.1 Purpose and Method of the Survey

Test borehole drilling was conducted at six (6) target sites (R1Muhasuwa, R2Mwatibu, R3Chimwalira, R4Kabekere, R5Mwalawanyenje, and R6Mzoma) to check the availability of a groundwater source which is necessary for the construction of water supply facilities. A local borehole drilling company in Malawi was selected as the subcontractor for this survey to carry out the drilling.

##### 1.2 Survey Period

The originally planned drilling work would last approximately two months from the early October to the end of November, 2013. However the plan was affected by the annual rainy season, the survey was completed almost as planned at six sites in the early December 2013.

##### 1.3 Summary of the Survey Results

###### (1) Water Quantity and Quality at the Six Sites

The test drilling results indicate the availability of groundwater to meet a daily water demand of 10 m<sup>3</sup> or more at the R1Muhasuwa, R2Mwatibu, R3Chimwalira, R4Kabekere, R5Mwalawanyenje, and R6Mzoma sites. In regard to the test drilling was smoothly conducted at six sites, and found groundwater in a good aquifer consisting of fissure/s of biotitic granitic rocks. However, the faecal coliform was found at two sites namely R4Kabekere and R6Mzoma, then re-samplings were conducted and confirmed safe drinking water quality for all six sites.

The drilling depth of six sites finally reached ranging from 51m to 67m, and the casing and screen was installed with some collapse of the soft formation. As the results of 24 hours constant discharge test pumping of six sites produced 31.2 m<sup>3</sup>/day to 96.0 m<sup>3</sup>/day, pumping rate of 1.29 m<sup>3</sup>/hour to 4.00 m<sup>3</sup>/hour. Then, it was judged that the drilling of six sites boreholes were successful as shown in Table 5, 6, 7 and Table 8, and would meet the likely water demand there.

In regard to the water quality, a water quality analysis officer of the Ministry of Water Development and Irrigation (MWDI) collected samples at the end of the pumping test at each site and checked their suitability as drinking water in reference to the drinking water standards of Malawi and the drinking water guidelines of the WHO. Because the first samples of four sites, R1Muhasuwa, R2Mwatibu, R3Chimwalira and R5Mwalawanyenje were the suitable for drinking, but the other two sites of R4Kabekere and R6Mzoma

indicated the presence of coliforms. Possibly because of the insufficient cleaning of the boreholes, a second sampling was conducted along with cleaning of the boreholes. The water quality analysis of the second samples confirmed that the water quality at the R4Kabekere and R6Mzoma sites was suitable for drinking.

We had the six successful test boreholes at six sites however test boreholes were drilled totally nine including three dry holes due to hydrogeological difficulty of R4Kabekere and R6Mzoma. Especially R4Kabekere CDSS located on the top of rocky hill and two dry holes were counted within the CDSS boundary. Therefore, the third one was drilled in village and found successful groundwater discharge. On the other hand, the first test borehole of R6Mzoma was collapsed due to soft formation, and the second one drilled successfully within the same area of CDSS boundary.

The exact location of each test borehole at six sites was determined using the GPS as shown in Table 1 and their locations were plotted on a Google Earth map (see Fig. 1 to Fig. 6).

Table 1 Results of the Test Drilling at Six Sites

Drilling Site	Borehole No.	Location		Depth of Borehole (Drilling Depth)	Borehole GPS Elevation	Water Demand at Site	Water Quality & Quantity Evaluation
		Latitude (South)	Longitude (East)				
1. Muhasuwa CDSS	R1 Muhasuwa No.1	15°50'30.0"S	35°15'36.1"E	67m (67m)	825m	9.8 m <sup>3</sup> /d	☉
2. Mwatibu CDSS	R2 Mwatibu No.1	14°04'56.9"S	33°54'53.5"E	60m (61m)	1060m	12.7 m <sup>3</sup> /d	☉
3. Chimwalira SS	R3 Chimwalira No.1	15°36'2.1"S	35°15'32.0"E	51m (51m)	901m	9.1 m <sup>3</sup> /d	☉
4. Kabekere CDSS	R4 Kabekere No.1	14°39'59.9"S	34°39'10.1"E	- (51m)	999m	Dry	X
	R4 Kabekere No.2	14°39'56.8"S	34°39'14.3"E	- (61m)	997m	Dry	X
	R4 Kabekere No.3	14°40'1.9"S	34°38'51.3"E	51m (51m)	983m	16.3 m <sup>3</sup> /d	☉
5. Mwalawanyenje CDSS	R5 Mwalawanyenje No.1	13°04'7.1"S	33°26'44.0"E	54m (56m)	1083m	9.8 m <sup>3</sup> /d	☉
6. Mzoma CDSS	R6 Mzoma No.1	12°09'2.6"S	33°20'51.5"E	- (52m)	1235m	Dry	X
	R6 Mzoma No.2	12°09'4.5"S	33°20'49.7"E	52m (56m)	1235m	10.5 m <sup>3</sup> /d	☉

(2) Specifications of the Boreholes for the Six Survey Sites

The test drilling was entrusted to Malawi local company to drill boreholes with the standard specifications in Malawi as shown in Table 2.

Table 2 The Test Borehole Specifications

<ol style="list-style-type: none"> <li>1) Diameter of test borehole: 6 inches,</li> <li>2) Average drilling depth: 60 m</li> <li>3) Screen/casing diameter: 6 inches (external diameter: 160 mm), PVC</li> <li>4) Installation of screens at the depth of the aquifer and gravel packing in the space between the borehole and the screens</li> <li>5) Borehole cleaning and development</li> <li>6) Pumping test (step-drawdown test, 24 hours constant discharge test and recovery test)</li> <li>7) Water quality analysis (in accordance with the guidelines of Malawi and the WHO Guidelines for Drinking-Water Quality)</li> </ol>
--

(3) Water Quality Analysis at the Six Sites

The water quality analysis of the sampled groundwater from the test boreholes was conducted at water quality analysis laboratories in Lilongwe of the MWDI Central Water Laboratory which are the official water test laboratories in Malawi in accordance with the drinking water guidelines of the WHO and Malawi's standards for boreholes for drinking water (2005). This analysis was conducted on the 21 standard test items shown in Table 3.

Table 3 Drinking Water Standards/Guidelines of Malawi and the WHO

	Water Quality Item	WHO	Malawi		Water Quality Item	WHO	Malawi
1	TDS	1,000	2,500	2	Turbidity	-	25
3	pH Value	6.5 - 8.5	6.0 - 9.5	4	Silicic Acid	-	-
5	Na	200	500	6	K	-	-
7	Mg	0	250	8	Ca	-	250
9	Fe	0.3	3.0	10	Total Hardness	200	800
11	SS	-	-	12	Alkalinity	-	-
13	Chlorides	250	750	14	Sulphate	250	800
15	Nitrate	50	45	16	Carbonate	-	-
17	Fluorine	1.5	6.0	18	Electric Conductivity	-	3,500
19	Coliforms	0/100 mL	50/100 mL	20	Hydrogen Carbonate	-	-
21	Common Bacteria	-	0				

#### (4) Hydrogeological Evaluation of the Six Survey Sites

The test drilling confirmed the availability of sufficient groundwater of suitable quality and quantity for drinking at all sites. Assuming that a target schools require a water supply ranging from 9.12 m<sup>3</sup>/day to 16.28 m<sup>3</sup>/day on eight hours pumping in a day, the pumping capacity is required more than 1.14 m<sup>3</sup>/hour to 2.04 m<sup>3</sup>/hour.

In the case of the successful test boreholes for which the borehole structure was finalised, the groundwater potential was estimated based on pumping tests, and the optimal motorized pump capacity and pump installation depth as recommended considering water demand in Table 4 and 5. The optimal motorized pump installation depth is considered to set with pumping capacity, drawdown and the location of screen to avoid fine sand coming from the aquifer to pump. (see to Appendix, Fig. 1 to Fig. 6, and for the borehole structure drawings).

Meanwhile, Table 6 and Table 7 show the hydrogeological evaluation, groundwater potential and sustainable discharge capacity results for the test drilling and pumping tests. (see to Appendix – Test Drilling Results by Site for a more detailed description of the pumping test as well as the water quality analysis results).

Table 4 Pump Installation Depth and Pumping Capacity Based on the Planed Water Demand at Site

Site and Borehole No.	Static Water Level (m)	Installed Pump Depth (m)	Pumping Water Level (m)	Drawdown (Water Level Drop)(m)	Specific Capacity (m <sup>3</sup> /hr/m)	Pumping Volume (m <sup>3</sup> /hr)	Water Demand at Site (m <sup>3</sup> /day)	Pumping Potential (m <sup>3</sup> /day) (8 hr pumping)
Symbol	E	M	O	P=O-E	H=D/G	Q=HxP	Planned	R8=Qx8 hr
R1Muhasuwa No.1	6.59	<b>45 m</b>	37.60 m	31.01m	<b>0.116</b>	3.60	<b>9.8</b>	28.8
R2 Mwatibu No.1	2.27	<b>42 m</b>	12.03 m	9.76m	<b>0.410</b>	4.00	<b>12.7</b>	32.0
R3Chimwalira No.1	9.90	<b>38 m</b>	23.34 m	13.44m	<b>0.268</b>	3.60	<b>9.1</b>	28.8
R4Kabekere No.3	10.93	<b>47 m</b>	18.01 m	7.08m	<b>0.508</b>	3.60	<b>16.3</b>	28.8
R5Mwalawanyenje No.1	7.13	<b>47 m</b>	26.42 m	19.29m	<b>0.067</b>	1.29	<b>9.8</b>	10.32
R6 Mzoma No.1	8.75	<b>47 m</b>	23.33 m	14.58m	<b>0.247</b>	3.60	<b>10.5</b>	28.8

Table 5 Constant Discharge Pumping Test (24 hours) and Recovery Test Results

Site	Constant Pumping Volume (m <sup>3</sup> /hr)	Pumping Test Duration (hrs/day)	Pumping Volume (m <sup>3</sup> /day)	Drawdown (m)	Recovery Test (Recovery Rate %)	Recovery Time (hrs)	Specific Capacity (m <sup>3</sup> /day/m)	Specific Capacity (m <sup>3</sup> /hr/m)
Symbol	D	T	S=DxT	G=F-E	U	V	W=S/G	H=D/G
R1Muhasuwa No.1	3.6	24	86.4	31.01m	90.7%	2.0	2.79	<b>0.116</b>
R2 Mwatibu No.1	4.0	24	96.0	9.76m	92.8%	1.5	9.84	<b>0.410</b>
R3Chimwalira No.1	3.6	24	86.4	13.44m	99.8%	0.5	6.43	<b>0.268</b>
R4Kabekere No.3	3.6	24	86.4	7.08m	98.6%	0.7	12.20	<b>0.508</b>
R5Mwalawanyenje No.1	1.3	24	31.2	19.29m	97.9%	1.0	1.62	<b>0.067</b>
R6 Mzoma No.2	3.6	24	86.4	14.58m	99.3%	0.3	5.93	<b>0.247</b>





Fig 1 Muhasuwa CDSS : R1- No.1 Successful test borehole (in green)



Fig. 2 Mwatibu CDSS: R2-No.1 Successful test borehole (in green)



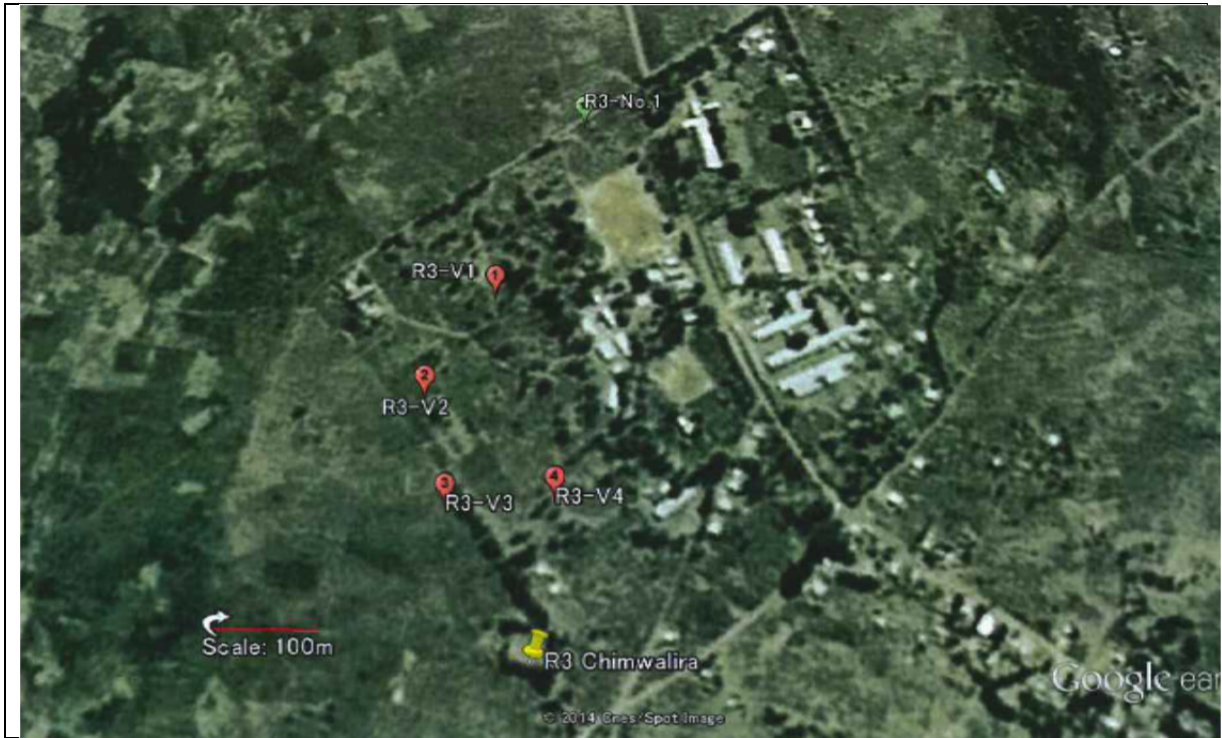


Fig. 3 Chimwalira CDSS: R2-No.1 Successful test borehole (in green)

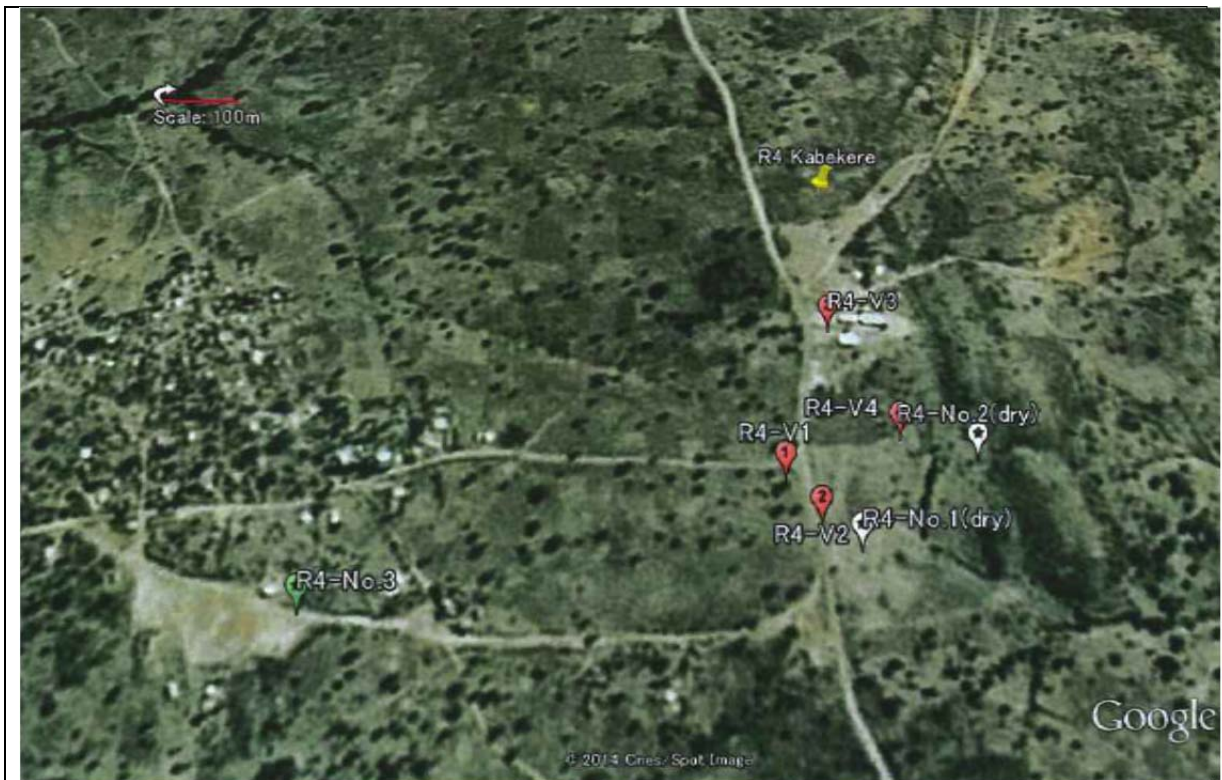


Fig. 4 Kabekere: R4- No.3 Successful test borehole (in green), R4-No.1 & No.2 Dry (in white)



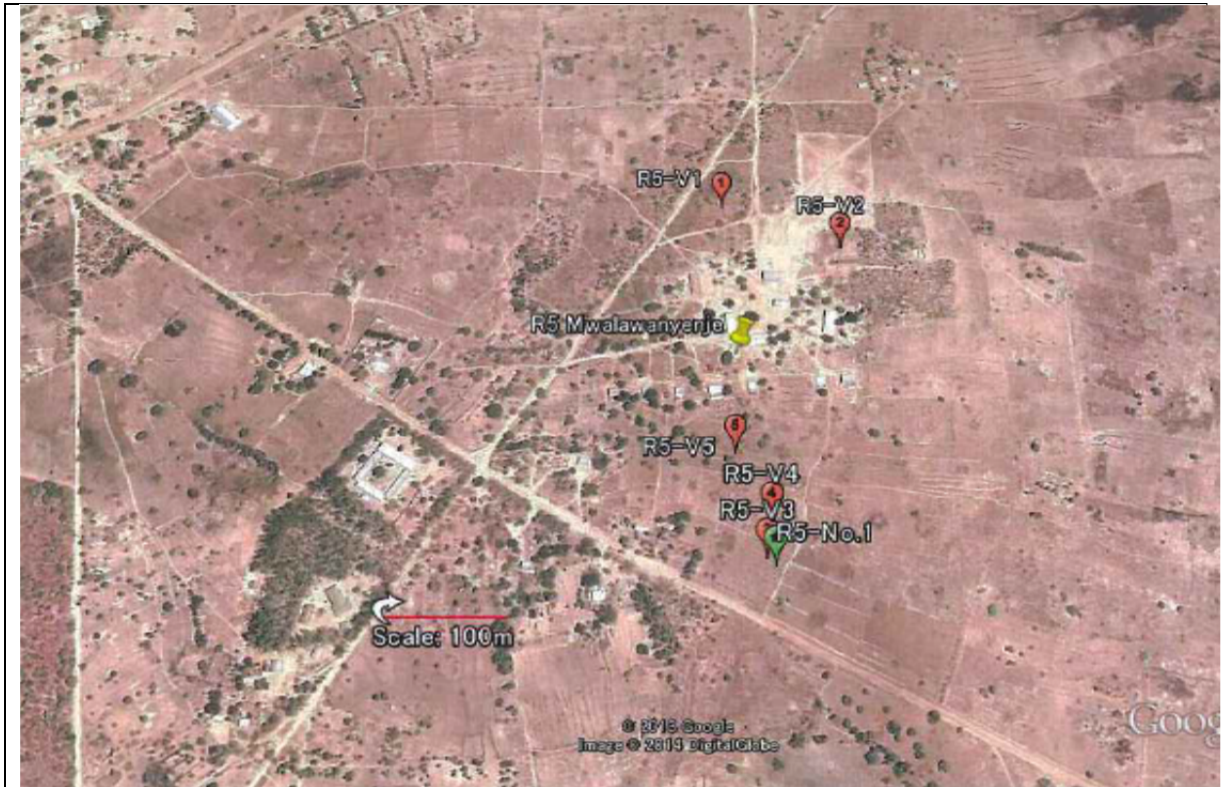


Fig. 5 Mwalawanyenje CDSS: R5- No.1 Successful test borehole (in green)



Fig. 6 Mzoma CDSS: R6- No.2 Successful test borehole (in green), R6-No.1 Dry (in white)

Table 7 Hydrogeological Evaluation of the Test Drilling of Boreholes

Site and Borehole Number	Borehole Diameter (mm)	Drilling Depth (m)	Borehole Depth (m)	Pumping Volume (m <sup>3</sup> /hr)	Static Level (m)	Pumping Water Level (m)	Drawdown (m)	Specific Capacity (m <sup>3</sup> /hr/m)	Aquifer	Screen Installation Depth (m)
Symbol	A	B	C	D	E	F	G=F-E	H=D/G	I	J
R1 Muhasuwa No.1	160	67	67	3.6	6.59	37.60	31.01	0.116	Fissure of Granites	31-43, 49-55, 58-61
R2 Mwatibu No.1	160	61	60	4.0	2.27	12.03	9.76	0.410	Fissure of Granites	6-9, 18-24, 30-33, 36-39, 45-48, 54-57
R3 Chimwalira No.1	160	51	51	3.6	9.90	23.34	13.44	0.268	Fissure of Granites	21-39, 45-48
R4 Kabekere No.1	160	51	-	-	-	-	-	-	Dry	-
R4 Kabekere No.2	160	61	-	-	-	-	-	-	Dry	-
R4 Kabekere No.3	160	51	51	3.6	10.93	18.01	7.08	0.508	Fissure of Granites	15-24, 30-39, 45-48
R5 Mwalawanyenje No.1	160	56	54	1.3	7.13	26.42	19.29	0.067	Fissure of Granites	24-45, 48-51
R6 Mzoma No.1	160	52	-	-	-	-	-	-	Dry-	-
R6 Mzoma No.2	160	56	52	3.6	8.75	23.33	14.58	0.247	Fissure of Granites	16-19, 25-40, 46-49

Table 8 Evaluation of Groundwater Potential and Pumping Capacity

Site and Borehole Number	Drilling Depth (m)	Borehole Depth (m)	Pumping Volume (m <sup>3</sup> /h)	Static W. Level (m)	Pumping W. Level (m)	Drawdown (m)	Specific Capacity (m <sup>3</sup> /hr/m)	Groundwater Potential (m <sup>3</sup> /h)	Sustainable Discharge (8 hr/day)	Pump Installation Depth (m)	Evaluation Result
Symbol	B	C	D	E	F	G=F-E	H=D/G	K=Hx20m	L=Kx8hr	M	N
R1Muhasuwa No.1	67	67	3.6	6.59	37.60	31.01	0.116	2.32	18.56m <sup>3</sup> /day	45m	⊙
R2 Mwatibu No.1	61	60	4.0	2.27	12.03	9.76	0.410	8.20	65.68m <sup>3</sup> /day	42m	⊙
R3Chimwalira No.1	51	51	3.6	9.90	23.34	13.44	0.268	5.36	42.88m <sup>3</sup> /day	38m	⊙
R4Kabekere No.3	51	51	3.6	10.93	18.01	7.08	0.508	10.16	80.8m <sup>3</sup> /day	47m	⊙
R5Mwawalawanyenje No.1	56	54	1.3	7.13	26.42	19.29	0.067	1.34	10.92m <sup>3</sup> /day	47m	⊙
R6 Mzoma No.2	56	52	3.6	8.75	23.33	14.58	0.247	4.94	39.52m <sup>3</sup> /day	47m	⊙

Note 1) the groundwater potential and sustainable discharge was evaluated using the unit of m<sup>3</sup>/average drawdown of 20m based on the pumping test results, and the required 8 hours pumping duration to meet the water demand for 9.1 to 16.3 m<sup>3</sup>/day was assessed to determine the viability of pumping operation in each site.