2.6 RESULTS OF GEOPHYSICAL EXPLORATION OF WATER QUALITY CHECK SITE

2.6.1 IGUNGA DISTRICT

(1) Igumo village

The survey location map is shown in Figure 2.6.1, and the interpreted sections of the geophysical exploration are shown in Figure 2.6.2.

An exploration was carried out around the lineament that was suggested by the regional satellite map (1:200,000).

- Igumo No.1

The range of resistivity of the north zone(max1500Ω-m) and the south zone(max600Ω-m) is different.

The higher resistivity on the north side suggested fresh bedrock. Therefore, in this area there is no possibility of groundwater development.

The south side has a resistivity structure that corresponds to the lineament.

Therefore, though the resistivity is high, this area can be expected to have possibility of groundwater development. 1 drill site was chosen (IG-007BH1).

(2) Buhekela village

The survey location map is shown in Figure 2.6.3, and the interpreted sections of the geophysical exploration are shown in Figure 2.6.4.

An exploration was carried out in the extension line of the lineament that was suggested by the regional satellite map (1:200,000).

- Buhekela No.1

At the center of the survey line, the resistivity section detected a zone that declines at 300Ω-m resistivity compared with the surrounding area. In addition, it is located on an extension of the lineament. Therefore this zone is thought to be a reflected fracture. 1 drill site was chosen (IG-012BH1).

- Buhekela No.2

The resistivity section detected an indistinct resistivity structure that has less resistivity at south of survey line. But the contrast of resistivity suggesting a fault or fracture was not recognized. In addition, the surrounding area has high resistivity. Therefore, the possibility is low that groundwater can be developed in this area.

(3) Kagongwa village

The survey location map is shown in Figure 2.6.5, and the interpreted sections of the geophysical exploration are shown in Figure 2.6.6.

An exploration was carried out in the distribution area of the sedimentary rock that was estimated from an existing geological map.

- Kagongwa No.1

The horizontal structure with low resistivity (<100Ω-m) had appeared from the surface to GL-40m. And a high resistivity zone(max 600Ω-m) is distributed over the bottom.

The low resistivity zone can be interpreted as sedimentary rock because the rock outcrops on the surface and the resistivity show a low value. The high resistivity zone indicates the granite which forms the bedrock.

- Kagongwa No.2

The detected structure is similar to No.1. In addition, the structure of the decline of resistivity was detected at the end of the survey line. This structure is estimated to have a fracture located in the bedrock.

There are not many differences in “Kagongwa No.1” and “Kagongwa No.2”.

The reason to select “Kagongwa No.1” as the drilling point is that it was able to determine that the sedimentary rock is distributed in this place because the sedimentary rock had an outcrop around “Kagongwa No.1”

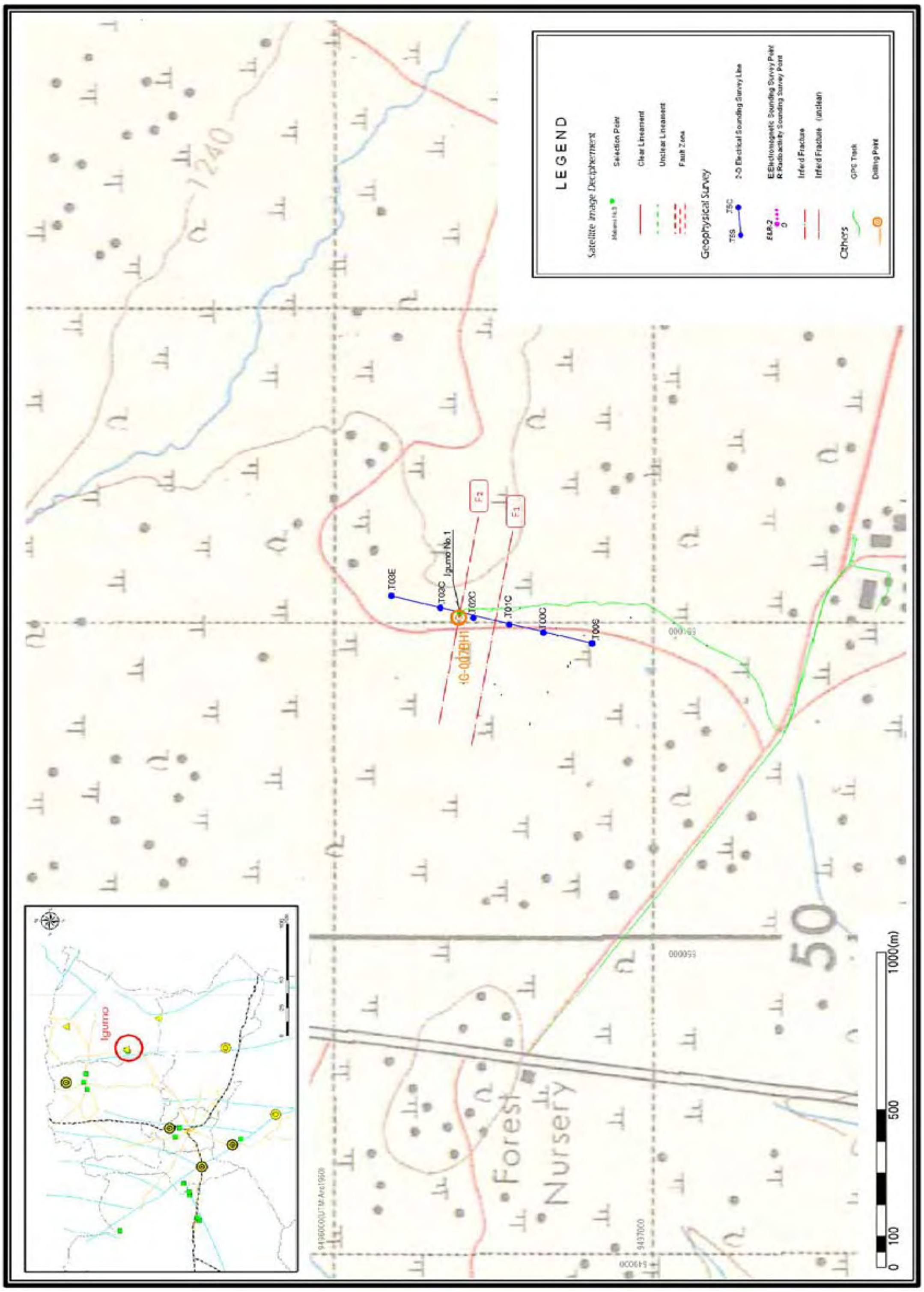

Figure 2.6.1 Layout of Geophysical Exploration（Water Quality Check Site　Igumo Village）

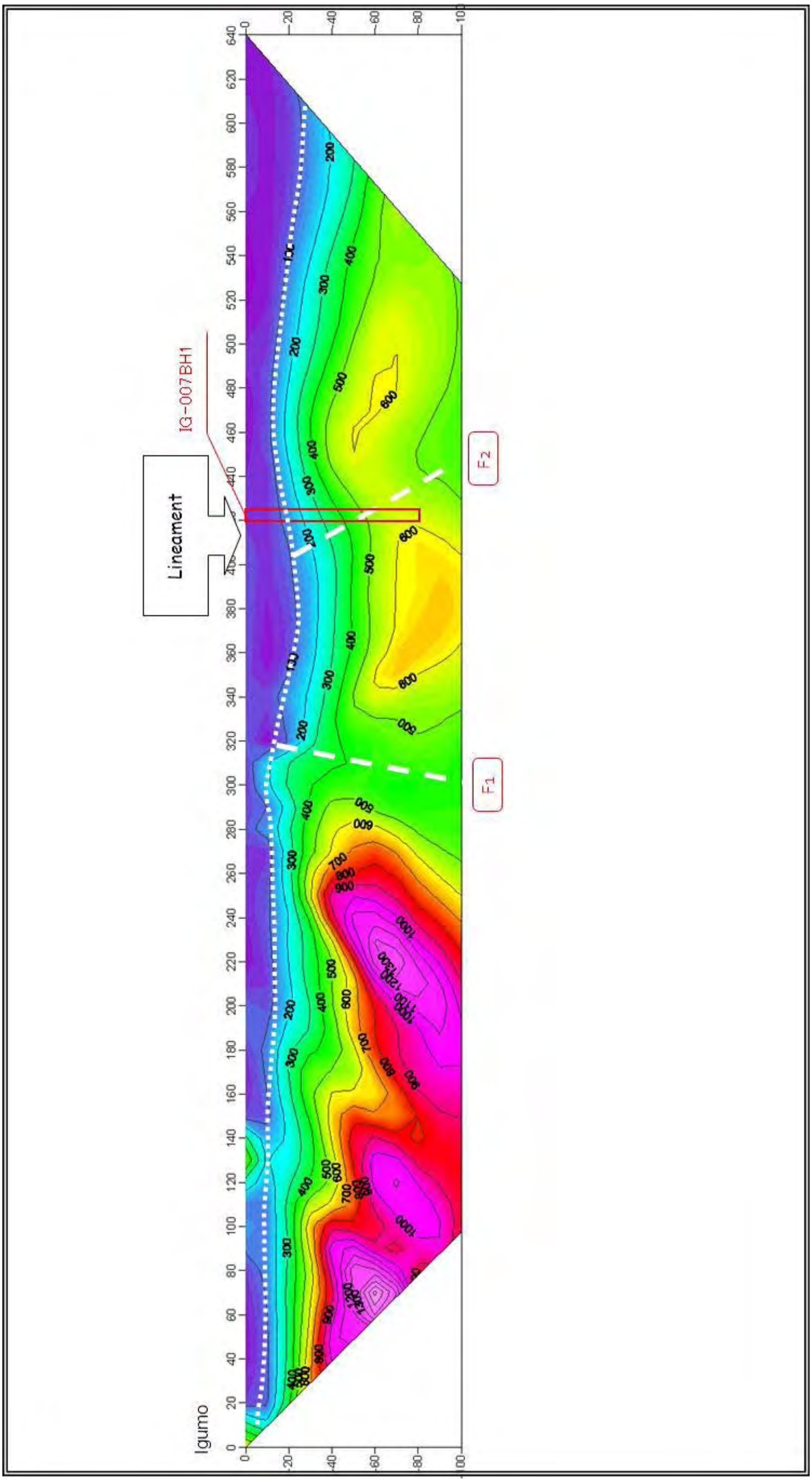

Figure 2.6.2 Results of Geophysical Exploration（Water Quality Check Site : Igumo Village）

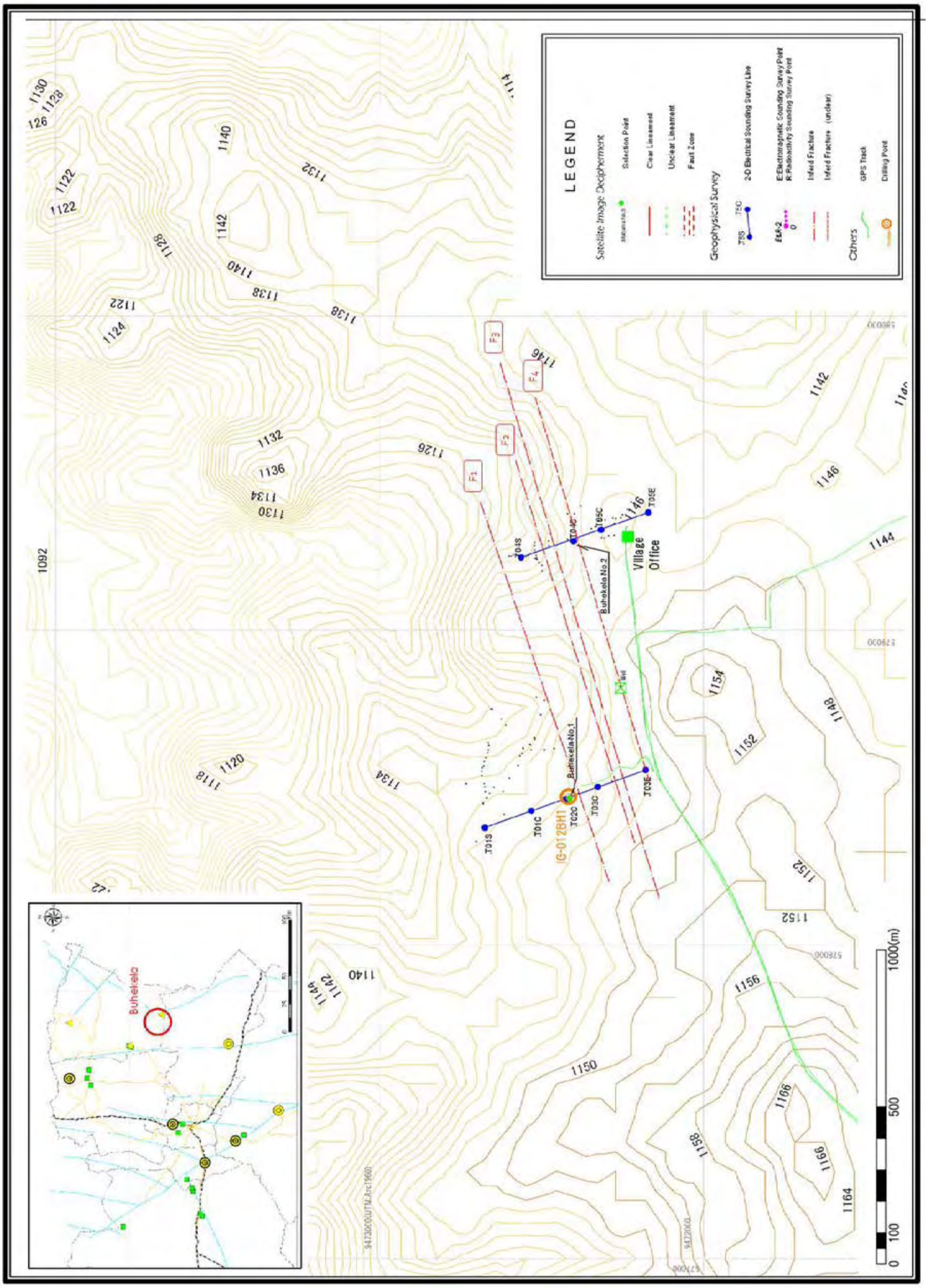

Figure 2.6.3 Layout of Geophysical Exploration (Water Quality Check Site Buhekela Village)

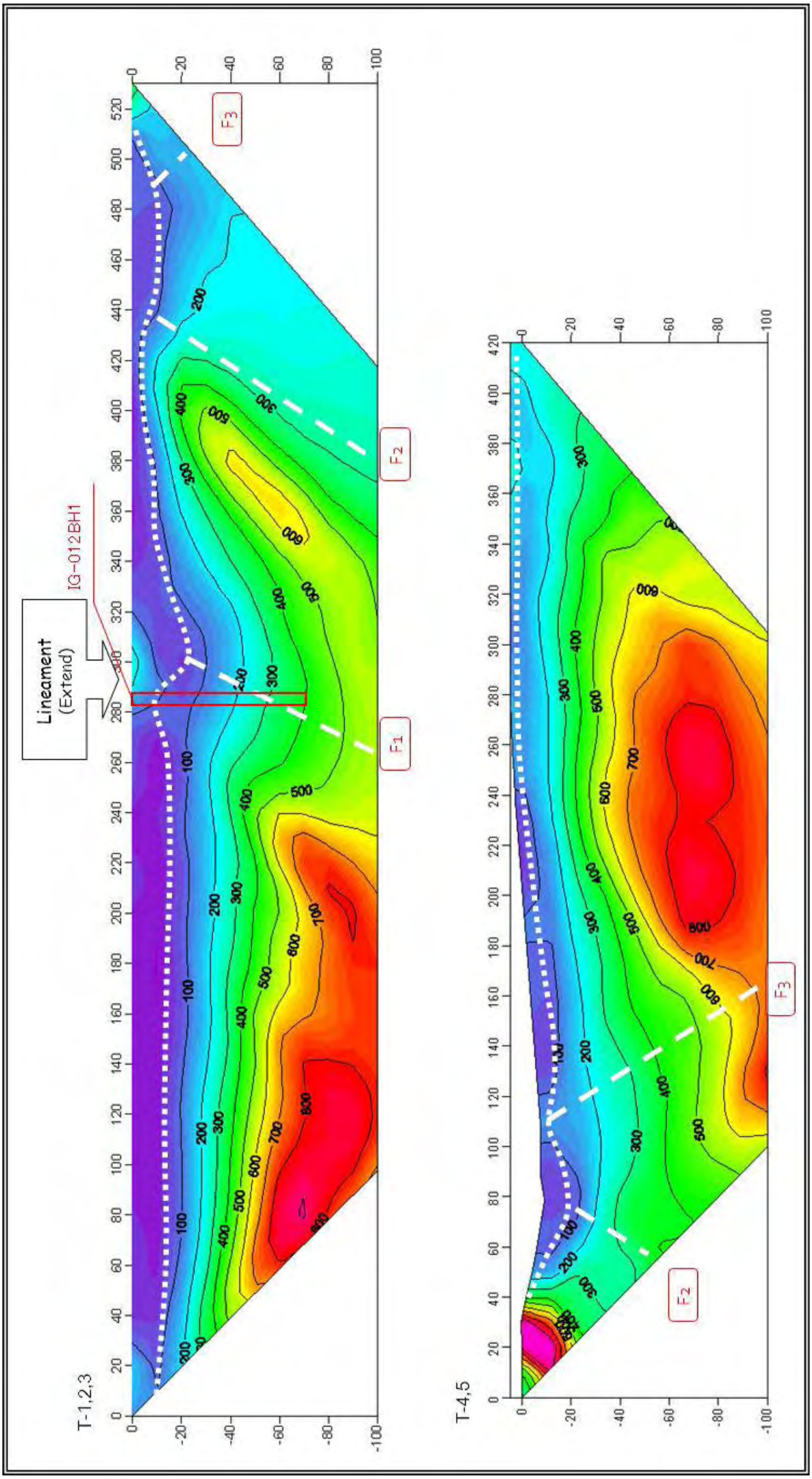

Figure 2.6.4 Results of Geophysical Exploration（Water Quality Check Site Buhekela Village）

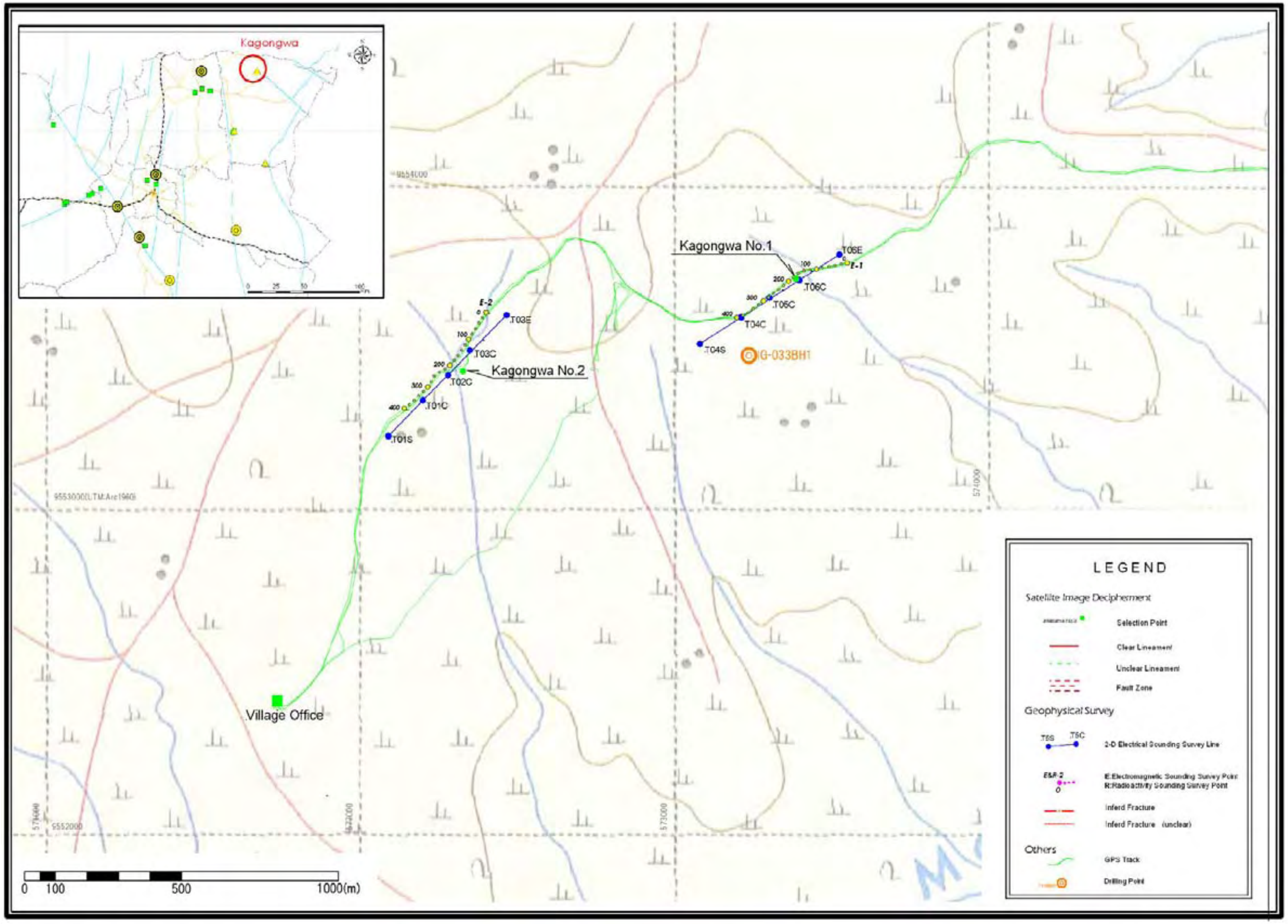

Figure 2.6.5 Layout of Geophysical Exploration（Water Quality Check Site　Kagongwa Village）

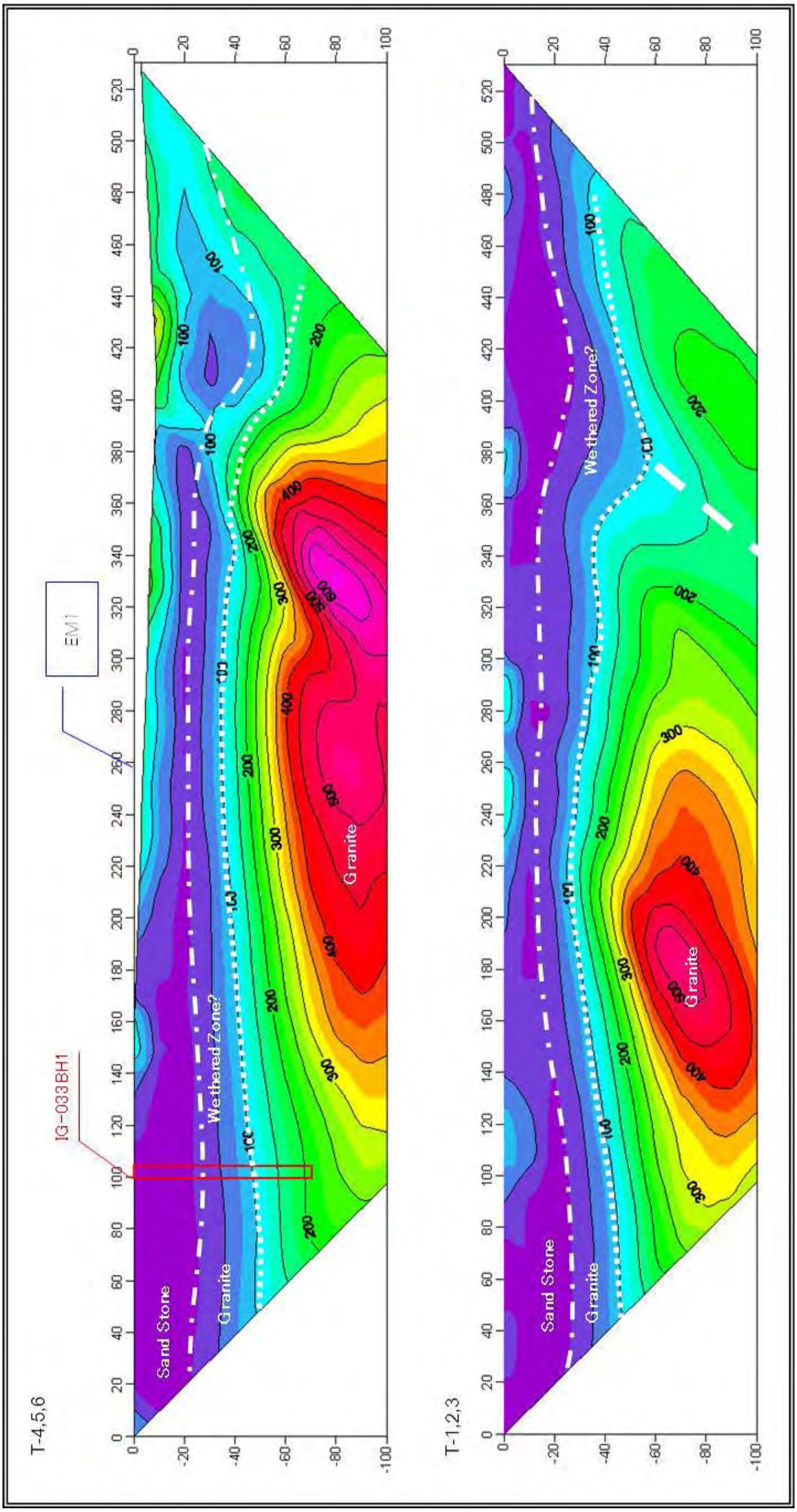

Figure 2.6.6 Results of Geophysical Exploration（Water Quality Check Site Kagongwa Village）

2.7 Conclusion of Geophysical Survey for Level-2 and Water Quality Check Site

The groundwater development of a bedrock zone that is similar to this area, requires a geophysical exploration.

The properties of the formations provided from the geophysical exploration and the geological information provided by test drilling results or the outcrop situation produce a highly precise result

The comparison results of the geological features and resistivity values are shown in the following.

Table2.7.1 Comparison of resistivity with geology

Geology			Resistivity range (Ω-m)	Average	Median
Alluvium	Unconsolidated sediment		10 - 60	33	30
Sedimentary rock	Sandstone		25 - 50	38	-
	Shall	Weathered or fractured	10 - 70	45	50
		Fresh	40 - 300	122	65
Igneous rock	Granite	Weathered or fractured	40 - 300	105	70
		Fresh	80 - 2000	860	700
Metamorphic rock	Crystalline schist		40 - 80	60	-
	Gneiss	Weathered or fractured	20 - 100	70	70
		Fresh	50 - 1500	430	190

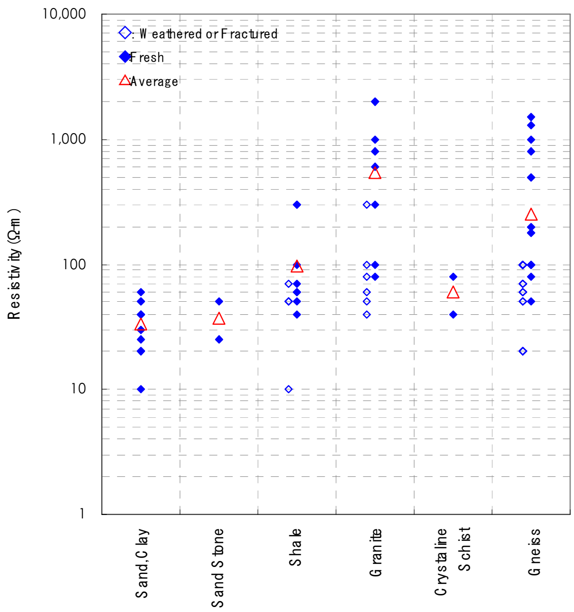

Figure 2.7.1 Relations of Resistivity with Geology

The correlation of geological features and the resistance value is admitted from the graph. But there is no clear boundary in resistivity value. Therefore it is difficult to presume geological formation only by resistivity.

A comparison of the data provided in the geophysical exploration with the critical yield provided in the test drilling is necessary.

The comparison results are shown in the following.

Table 2.7.2 The relationship between results of geophysical exploration and critical yield

BH No	data definition				coherence of each data		Critical Yield (m³/h)
	A Satellite image interpretation	B Radon method	C EM Method	D 2D electrical sounding	Type	Quality of Coherence	
TR-069BH1	○	○	△	◎	BD	○	14.0
TR-054BH2	◎	×	△	◎	AD	○	6.0
TU-008BH1	◎	◎	×	◎	ABD	◎	6.0
NZ-047BH1	◎	○	○	◎	ABD	◎	3.7
NZ-047BH2	◎	○	○	○	AD	○	3.0
IG-007BH1	△	−	−	○	AD	○	1.0
TR-069BH2	○	○	△	◎	BD	○	0.8
SK-028BH2	○	△	○	○	ABD	○	0.8
SK-028BH1	△	−	−	◎	AD	○	0.2
SK-037BH2	○	×	○	○	AD	○	0.1
TR-054BH1	◎	×	○	◎	AD	○	Dry
SK-037BH1	○	△	△	○	AD	○	Dry
IG-033BH1	−	−	○	○	-	×	Dry
IG-012BH1	−	−	−	○	-	×	Dry
TR-069BH3	○	○	△	○	-	×	Dry
TR-098BH1	△	−	−	△	AD	○	Dry

◎: Excellent ○: good △: fair ×: poor −: Not carried out

The result of the examination is as follows.

- **The success rate is low in a place where satellite image interpretation is not carried out.**
  →Because the often occurs that the groundwater in the bedrock is influenced by the structure (fracture, fault)
- **It is difficult to do development of groundwater by a combination of the radon method and the EM method**
  →Because the density of the data is not precise.
- **A great deal of groundwater can be expected when the result of the 2D electrical sounding and the radon method is clearly defined and has a high coherence**
  →Improve accuracy of the survey, because can multilaterally examine the value of different physical properties.

From the above-mentioned , 1) detailed photo interpretation, 2) high-density survey such as 2D electrical sounding 3)some surveys were carried out that obtained different physical properties, and a multidirectional analysis.

It is thought that it will contribute to improve accuracy when these three procedures are consistently carried out.

CHAPTER 3 TEST WELL DRILLING

3.1 GENERAL

A total of 16 test wells were drilled in total 10 villages of 4 districts and 1 city (except Urambo district). Study team member supervised and analyzed the test well drilling.

In this chapter, general specifications of boreholes, geological observation and water quality change of each borehole are described. And geological features are discussed.

3.2 PURPOSE

In order to know ground water potential to design a water supply facility, a total of 13 boreholes were drilled for 7 villages (2 boreholes for 1village in Nzega district, 1 borehole for 1 village in Tabora Municipality, 6 boreholes for 3 villages in Tabora Rural District, 4 boreholes for 2 villages in Sikonge district). In addition, to find ground water quality, 3 boreholes were constructed for 3 villages in the Igunga district.

3.3 METHOD

3.3.1 SURVEY SITES AND PERIOD

Drilling sites are shown in the table 3.3.1. All drilling points are determined by geophysical survey prior to this test well drilling works. Figure 3.3.1 shows drilling sites on geological map.

Site working started on 17/August/2010 and completed on 08/November/2010.

Table 3.3.1 Test Well Drilling sites list

District	Village	Drilling No.	Coordinate		
				X	Y
Nzega	Isanga	NZ-047BH1	36M	0523911	9550830
		NZ-047BH2	36M	0524030	9550844
Sikonge	Usunga	SK-028BH1	36M	0492530	9368238
		SK-028BH2	36M	0494744	9368375
	Mpombwe	SK-037BH1	36M	0466529	9402556
		SK-037BH2	36M	0465785	9405719
Tabora Rural	Mpumbuli	TR-054BH1	36M	0549469	9413752
		TR-054BH2	36M	0549535	9413742
	Mabama	TR-069BH1	36M	0448218	9433981
		TR-069BH2	36M	0448362	9433208
		TR-069BH3	36M	0448517	9433250
	Ufuluma	TR-098BH1	36M	0432350	9447793
Tabora Municipality	Kakola	TU-008BH1	36M	0482083	9462843
Igunga	Igumo	IG-007BH1	36M	0551014	9495593
	Buhekela	IG-012BH1	36M	0578471	9472418
	Kagongwa	IG-033BH1	36M	0573228	9553481

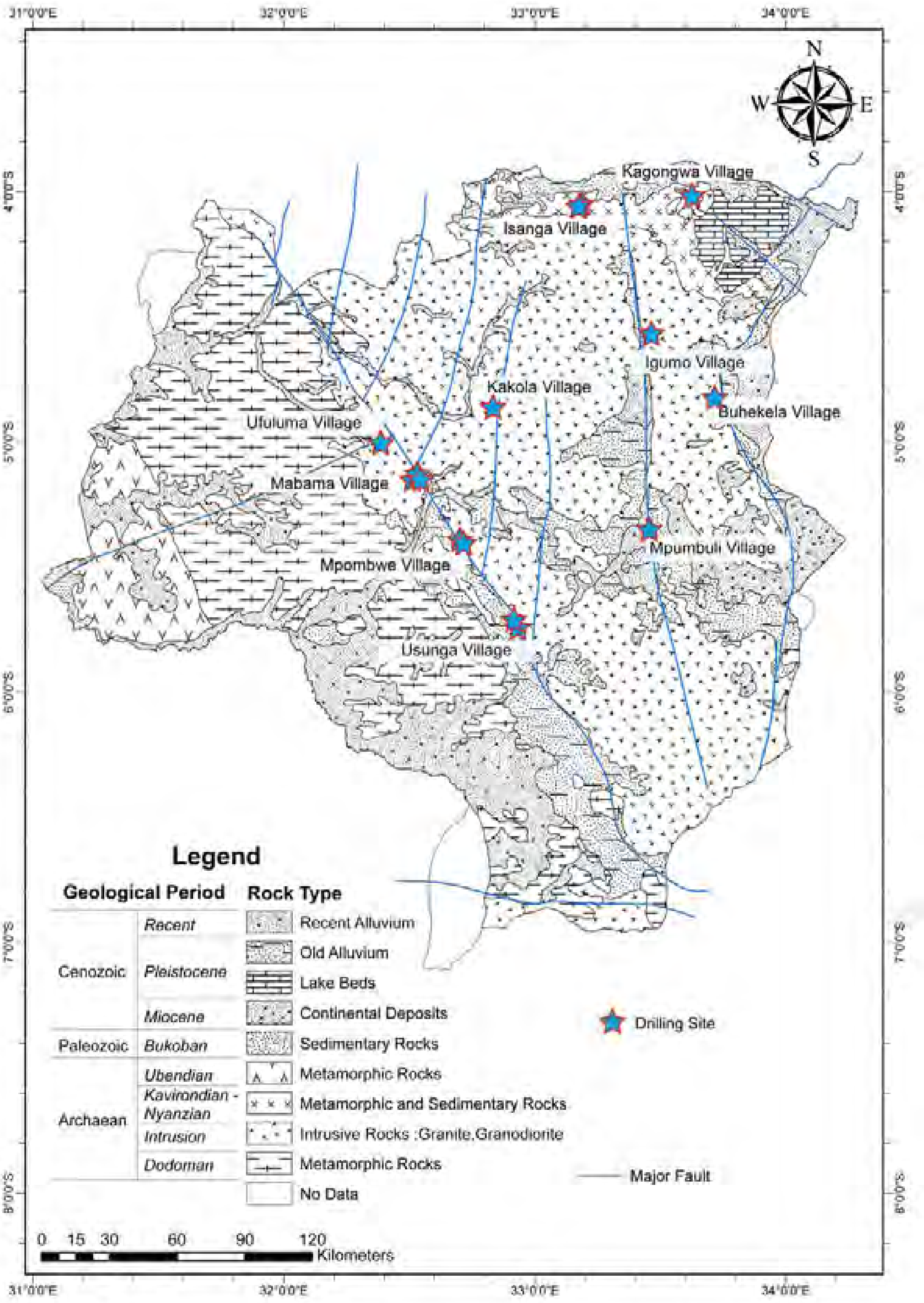

Figure 3.3.1 Drilling Site Map	
The Study on Rural Water Supply in Tabora Region	**JICA**

3.3.2 GENERAL SPECIFICATION OF CONSTRUCTION

(1) Borehole specification

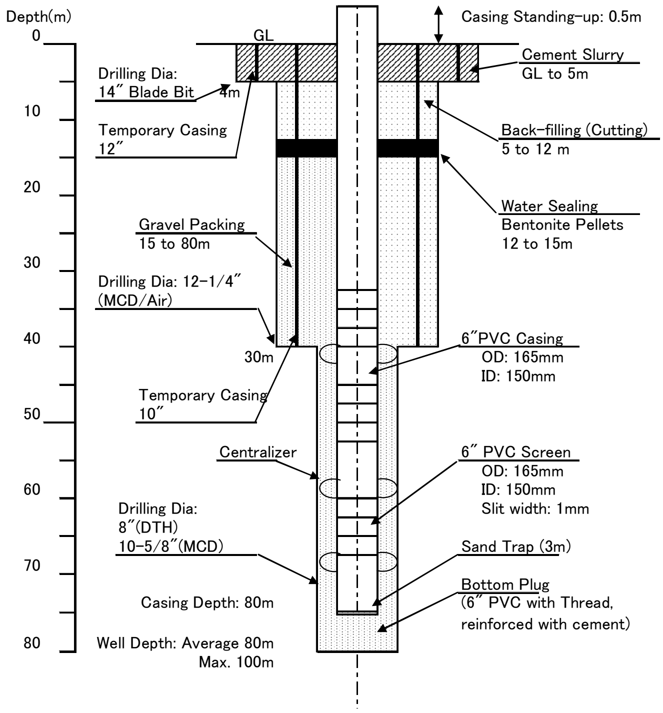

Figure 3.3.2 Borehole specification

To prevent soil collapsing, a temporary casing(φ12”) was installed. The down the hole hammer drilling method is taken at most drilling sites. In case the shallow unconsolidated zone is prone to collapse, the mud circulation drilling method is taken. After confirmation of water yield, a PVC casing(φ6”) is installed for permanent use.

(2) Logging

Certain information like accurate geological boundaries, fracture distribution etc. might be difficult to be recognized on those rock cuttings. Geophysical logging (resistivity, self-potential and gamma ray intensity) is carried out in order to analyze the sub-surface geological situation.

1) Machine model

Manufactured by Oyo Corporation Geologer 3030

2) Measuring parameters

i) Resistivity (short and long)

A Resistivity distribution curve is used to discriminate rock conditions like unconsolidated strata, crystalline, fracture etc.

ii) Self-Potential (SP)

Measured SP values include several factors, like a“battery” arising from the interaction between aquifer and mud layer, flow potential and ORP. SP curve can be used to determine aquifer horizon and more probably analyze ORP of the ground water.

iii) Gamma Ray Intensity

Gamma ray is mainly radiated from clay mineral. Gamma ray intensity curve shows rough rate of clay.

(3) Pumping Test

A preliminary test, step drawdown test, constant discharging rate test and recovery test were carried out for those boreholes which were installed with PVC casing. Basically the step draw-down test consists of five steps and 2 hours for each step though the total steps pumping duration were reduced in some cases depending on water yield volume. The maximum discharge rate was analyzed based on the step drawdown test was adopted as discharge rate of constant rate test.

(4) Water Quality Analysis

1) Parameter

Table 3.3.2 Parameters of water quality analysis

Parameters to be analyzed

Aspects and Items			Unit	Tanzanian Standard (2008) *1	WHO Guideline (2008) *2
Microbial aspects	1	Total coliform bacteria	count/100ml	0	-
	2	Escherichia Coli	count/100ml	0	0
Chemicals that are of health significance	3	Cadmium (Cd)	mg/l	0.05	0.003
	4	Lead (Pb)	mg/l	0.10	0.01
	5	Arsenic (As)	mg/l	0.05	0.01
	6	Fluoride (F)	mg/l	4.0	1.5
	7	Nitrate (NO_3)	mg NO_3/l	100	50
	8	Nitrite (NO_2)	mg NO_2/l	-	3 / 0.2
	9	Nickel (Ni)	mg/l	-	0.07
	10	Manganese (Mn)	mg/l	0.5	0.4
Acceptability aspects	11	Hardness	mg/l	600	-
	12	Calcium (Ca)	mg/l	-	-
	13	Magnesium (Mg)	mg/l	100	-
	14	Iron (Fe)	mg/l	1.0	-
	15	Zinc (Zn)	mg/l	15.0	-
	16	Copper (Cu)	mg/l	3.0	2.0
	17	Chloride (Cl^-)	mg/l	800	-
	18	Total filterable residue*4	mg/l	2,000	-
	19	Ammonium (NH_3+NH_4)	mg/l	-	1.5
	20	pH	-	6.5 - 9.2	
	21	Taste	dilution	not objectionable	-
	22	Odour	dilution	not objectionable	-
	23	Colour	mg Pt/l	50	15
	24	Turbidity (Tr)	NTU	30	5
	25	Temperature	℃	-	-
	26	Conductivity (EC)	mS/m	-	-
Water quality items related to the characteristics of groundwater	27	Sodium (Na)	mg/l	-	-
	28	Potassium (K)	mg/l	-	-
	29	Bicarbonate (HCO_3^-)	mg/l	-	-
	30	Sulfate (SO_4^{2-})	mg/l	600	-

*1: "Maji Review" Ministry of Water Development and Power vol. 1, No. 1, MoWDP, Dar es Salaam, 2008
*2: "WHO Guideline for Drinking Water Quality Third Edition", World Health Organization, Genova, 2008

2) Simple method used in the study team office

Simple analysis by the study team

Fluoride concentration, pH and electric conductivity are measured by equipment owned by the study team. 2 pieces of equipment are used for measuring Fluoride to take errors between machines into account.

Furthermore oxidation reduction potential of yielded water was measured on site in Kakola village (BH1) and Mabama village (BH1).

ⅰ) Fluoride concentration and pH
Manufactured by TOA DKK Corporation　Portable ion /pH meter IM-22P
Method : Ion electrode method

ⅱ) Electric conductivity
Manufactured by TOA DKK Corporation　Electric conductivity meter CM21-P
Method : Alternating current bi-pole method

ⅲ) Oxidation reduction potential
Manufactured by EUTECH Corporation　Ecoscan

Official Analysis (30 items)

(Organization)
KARMEL CONTRACTORS AND SUPPLIERS LIMITED
Dar Es Salaam

(Equipment)
Manufactured by Wagtech　Photometer 7100
Method for Fluoride: Zircon- Eriochromecyanine R method

3.4 RESULT

3.4.1 NZEGA DISTRICT

(1) Isanga Village (BH1)

1) Site works / Geology

Unconsolidated sediments lies above the 20m depth. Shale was distributed below 20m depth. 20-44m is moderately weathered zone. Below 44m is a fresh rock zone. Fractures are oxidized. The negative shift of resistivity is coincide with the depth where water yield increased. The grain size of shale is invisible to the naked eye. It means less than silt size. Although normally the gamma ray intensity of shale is relatively high, the taken values are less than 3 cps, it’s not so high. It indicates that clay mineral contents are not so high. See the Data Book E.1 and E17 for the detailed description.

Pumping test result is described in 3.4.1(3).

2) Water quality

Figure 3.4.1 shows the water quality change through site works.

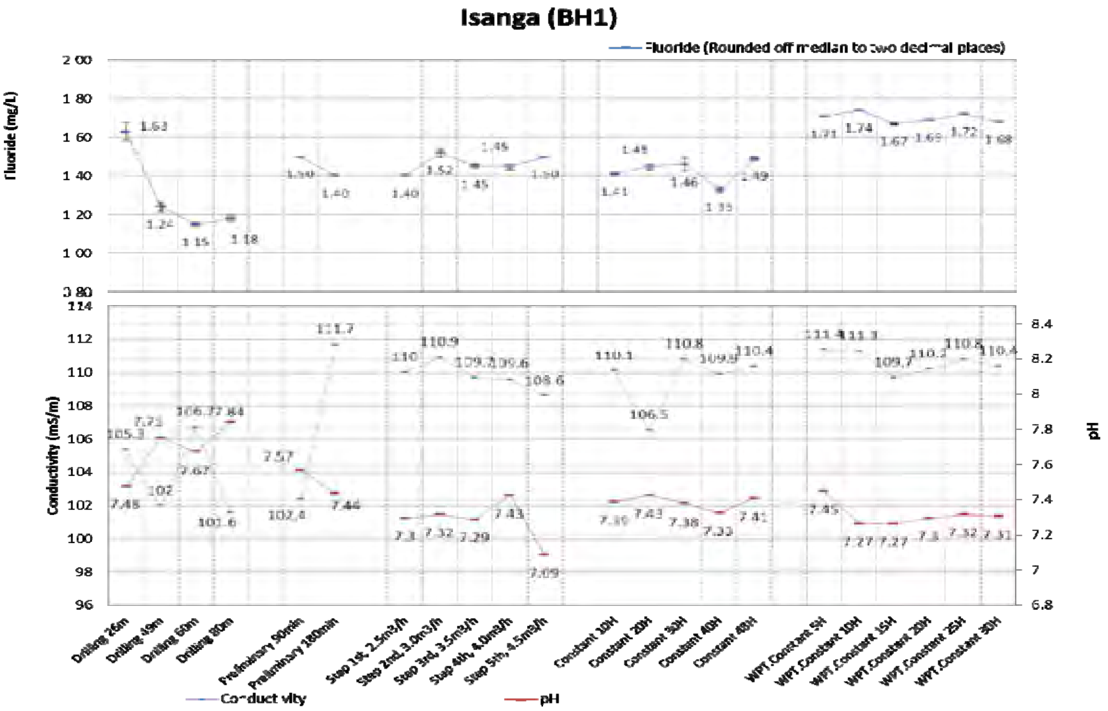

Figure 3.4.1 Water quality change through site works in Isanga Village BH1

3） Water quality of nearby shallow water

Table 3.4.1 Shallow water quality of Isanga Village

Well Type	Coordinate			Well Depth	F (mg/l)	pH	Conductivity (mS/m)	Distance from Drilled Point(km)
NPW*1	36M	0523832	9550665	3m	9.3 – 9.5	9.4	190.09	0.18 km
River	36M	0524156	9550934	1m	1.36-1.39	-	-	0.26 km

*1 Non Protected Well

(2) Isanga Village (BH2)

1) Site works / Geology

Shale distributed bellow 4m depth which is shallower than the Isanga BH1. Above 40m depth is moderately weathered. Fractures are oxidized. Those features of the rock and logging result are almost the same as BH1.

Because the distance between BH1 and BH2 is so close (120m), simultaneous pumping test was carried out (see 3.4.1(3)).

See the Data Book E.2 and E18 for the detailed description.

2) Water quality

Figure 3.4.2 shows the water quality change through site works.

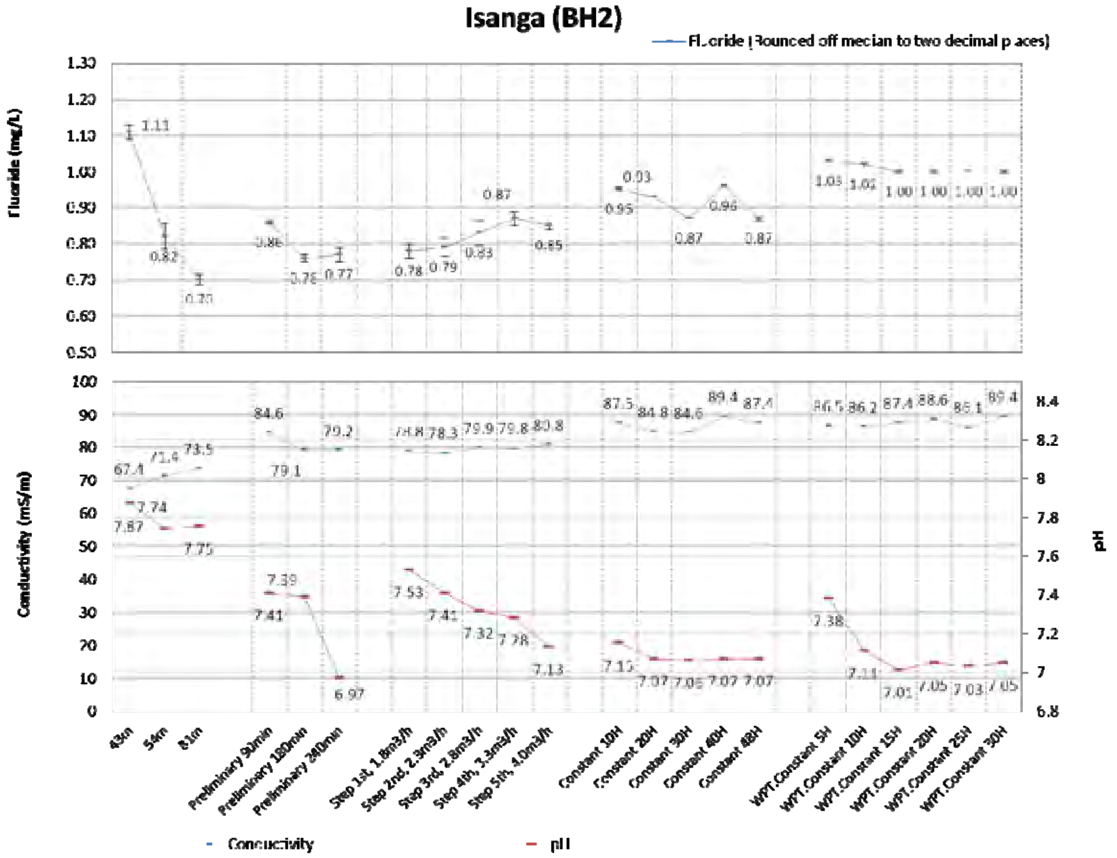

Figure 3.4.2 Water quality change through site works in Isanga Village BH2

3) The pumping test of BH1 and BH2 in Isanga Village

Because the distance between BH1 and BH2 is only 120m, there was a fear of the interaction of draw down during pumping. Therefore during the single pumping test, the water level of another borehole was checked whether there was draw down. Furthermore, simultaneous pumping test of BH1 and BH2 boreholes was carried out.

As a result, any interaction of draw down was not recognized through the pumping test.

See the Data Book E.19 and E20 for the analysis.

3.4.2 Sikonge District

(1) Usunga Village (BH1)

1) Site works / Geology

Though there were several fractured and slightly oxidized zones the, water did not came constantly.

Geophysical logging shows a negative shift of resistivity and positive shift of Gamma rays and negative shift of SP around 70m. This depth corresponds to an oxidized fracture involving clay. These facts may indicate that the clay decreases permeability of the fracture zone though there is an influx of reductive water.

Because there is a possibility that air pressure of drilling compressor prevents water coming from the thin fracture, PVC casing was installed to carry out a pumping test. The Pumping test showed that the water yield is only 0.18 m^3/h and was declared negative.

See the Data Book E.3 and E22 for the detailed description.

2) Water quality

Figure 3.4.3 shows the water quality change through site works.

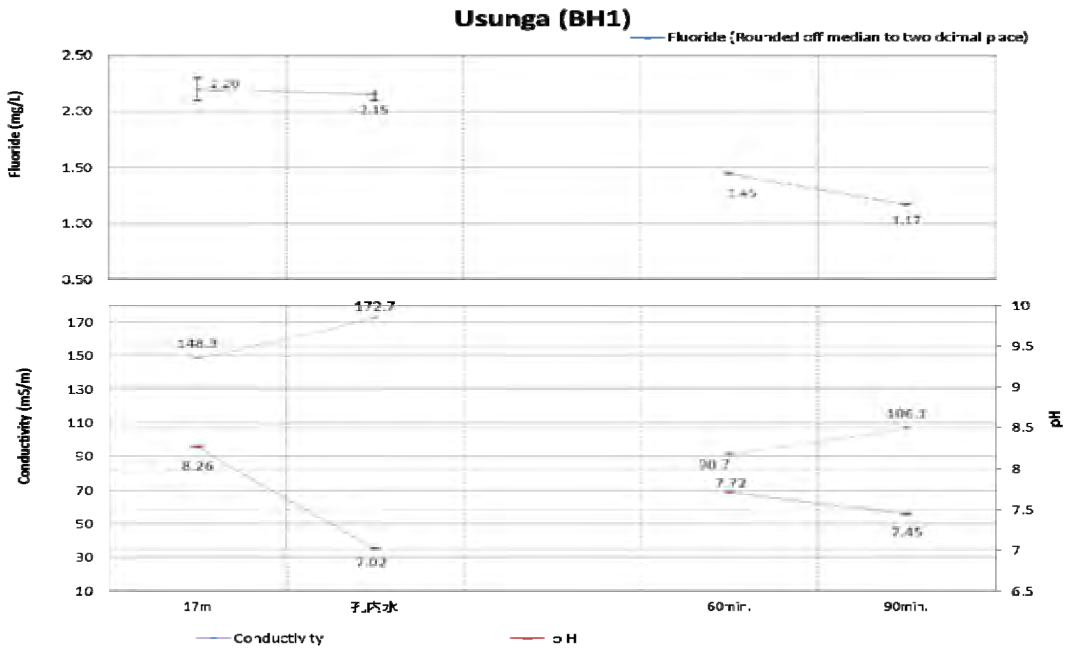

Figure 3.4.3 Water quality change through site works in Usunga Village (BH1)

(2) Usunga Village (BH2)

1) Site works / Geology

In Mpombwe village and Usunga village, the same type of rock is distributed. Majore fracture zones with water were around 49m and 60m (quartz rich) and below 103m (mafic zone). Assumed fracture zone by 2-Dimension Resistivity diagram corresponds to mafic mineral rich zone. Oxidized fractures involve semi-consolidated clay which may fill the fracture to prevent ground water flow.

A relatively high resistivity zone corresponds to quartz rich horizon. Low resistivity zones do not always correspond to oxidized fracture zones but to mafic zones.

The SP curve shows a moderate deepening negative shift and negative spikes correspond to an oxidized zone (around 90m, 115m, 130m). This implies existence of influx of reductive water.

The Pumping test showed the water yield is 0.8 m^3/h and declared positive for s handpump water supply facility.

See the Data Book E.4 and E.22 for the detailed description.

2) Water quality

Figure 3.4.4 shows the water quality change through site works.

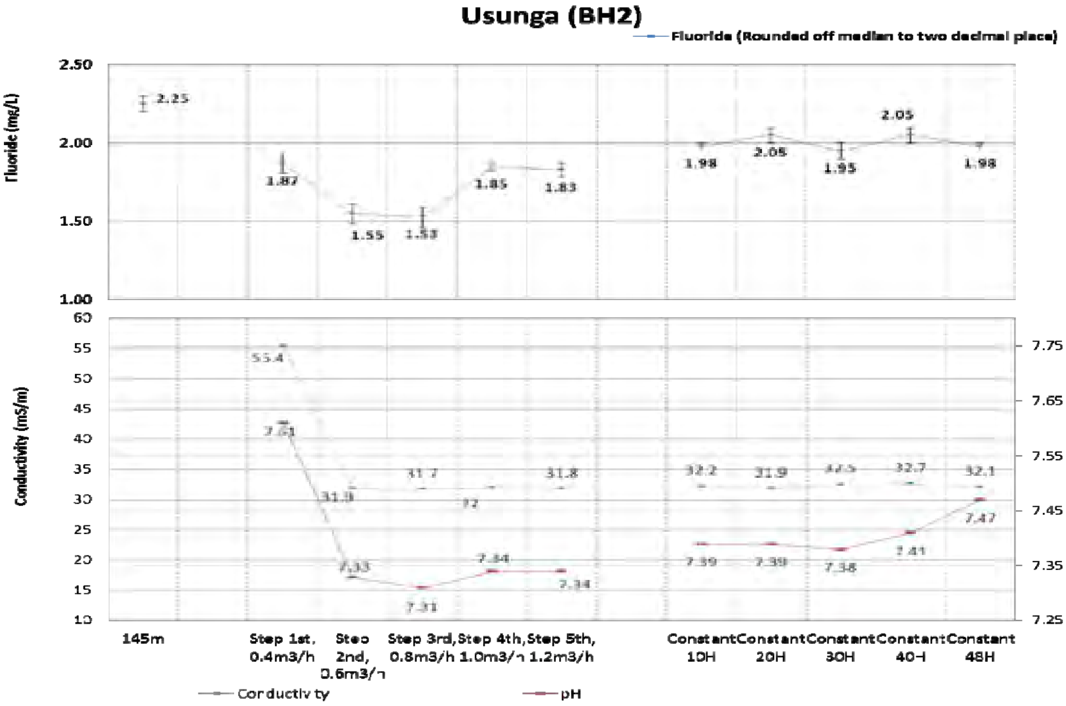

Figure 3.4.4 Water quality change through site works in Usunga village (BH2)

3) Water quality of nearby well

Table 3.4.2 Water quality of shallow wells in Usunga village

Well Type	Coordinate			Well Depth	F (mg/l)	pH	Cond. (mS/m)	Dist. from Drilled Point BH1
SW HP 1	36M	0496412	9365075	8 m	0.37-0.39	6.11	24.3	3.8 km
SW HP 2	36M	0496460	9375050	6 m	0.39-0.42	6.3	19.5	8.0 km
SW HP 3	36M	0492826	9369075	6 m	0.20-0.21	5.9	18.2	2.6 km
NPW	36M	0492721	9368314	3 m	0.52 – 0.54	6.96	35.9	2.0 km

SW HP = Shallow Well Hand Pump. NPW = Non Protected Well

(3) Mpombwe Village (BH1)

There was no water although the rock was slightly oxidized around 22m, 29m and 72m. Oxidized fractures involve semi-consolidated clay. We measured the water level the next day. The water level was 77m (drilled depth is 79m). So the water column is only 2m. This borehole was declared negative. Geophysical logging, pumping test water quality analysis were not carried out because it’s a dry borehole.

See the Data Book E.5 for the detailed description.

(4) Mpombwe Village (BH2)

1) Site works / Geology

Approximately 1.0 m^3/h of water came from the fracture around 24-25m depth. But below this depth, there were only minor and thin fractures. Below 40m, thin fractures increased and the penetration rate accelerated though water yield was only damp sand. Because there is a case that air pressure of drilling compressor prevents water coming from a thin fracture, PVC casing was installed to carry out pumping test.

Logging was carried out after poured water into the borehole because the water recovery was very slow. There are slight negative shifts of resistivity around 42m, 52m, 58m, 70m, 80m and 85m.

The Gamma ray values are relatively low as a whole. These depths correspond to quartz rich facies and are slightly oxidized. The Deepening negative shift of SP curve may indicate influx of reductive water.

The Pumping test showed that water yield is only 0.14 m^3/h and declared negative.

See the Data Book E.6 and E23 for the detailed description.

2) Water quality

Figure 3.4.5 shows the water quality change through site works.

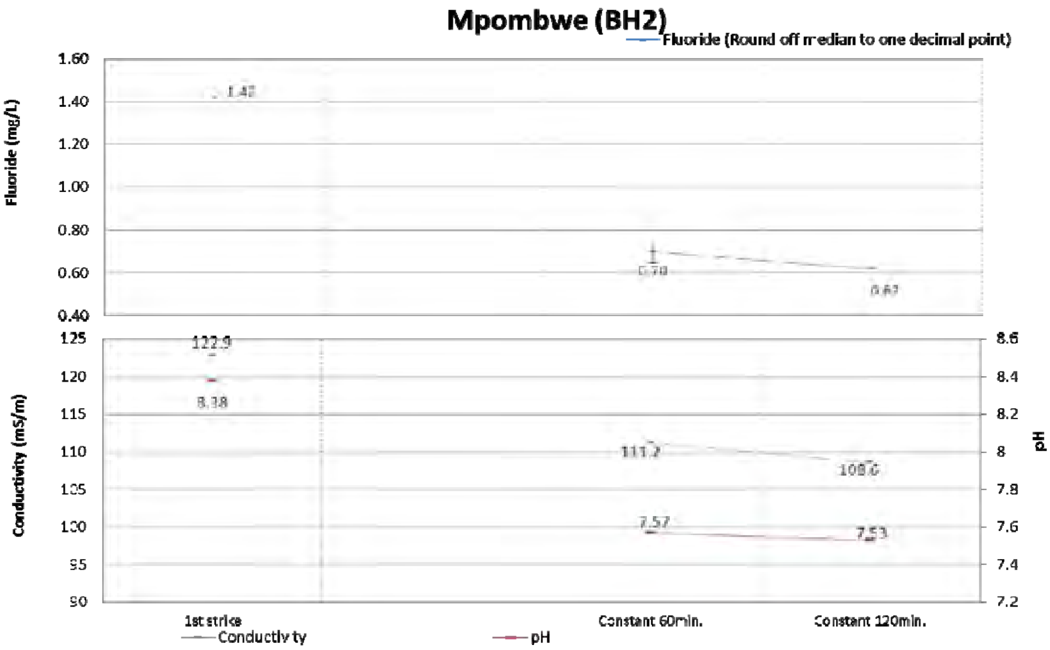

Figure 3.4.5 Water quality change through site works in Mpomwe Village (BH2)

3.4.3 TABORA RURAL DISTRICT

(1) Mpumbuli Village (BH1)

Unconsolidated – semi-consolidated sand and mud sediments lies. There was no water except damp sand around 40m depth.

A 2-dimension resistivity diagram shows another possibility to get water is below 70-80m. The Second borehole in this village would be a deep borehole. So we stopped drilling at 50m and declared it negative to save the total drilling depth.

See the Data Book E.7 for the detailed description.

(2) Mpumbuli Village (BH2)

1) Site works / Geology

Unconsolidated sediments lie above 57m depth. Dark gray hard shale is distributed below 57m. The shale is fractured and oxidized moderately through this borehole. Slicken line and slicken side are recognized on those rock cuttings. They are evidences of a fault. The Fracture concentrating zones are 92-94m, 114-115m and 118-120m.

The Negative shift of resistivity logging curve corresponds to a fracture zone.

SP logging curve shows some negative spikes and downward negative shift. It implies that the deep zone is in a reductive environment and influx of reductive ground water into the borehole.

See the Data Book E.8 and E.24 for the detailed description.

2) Water quality

Figure 3.4.6 shows the water quality change through site works.

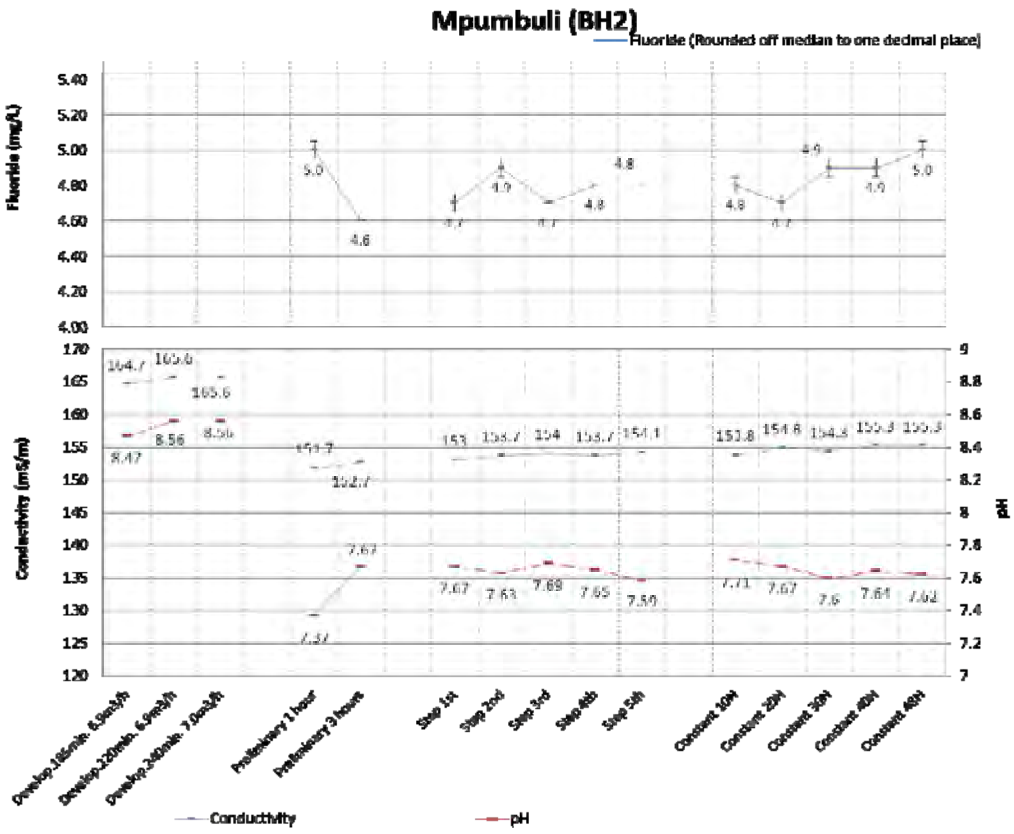

Figure 3.4.6 Water quality change through site works in Mpumbuli (BH2)

Fluoride changes in a range of 4.6-5.0 mg/l. The concentration increases through pumping. Finally the fluoride of Mpumbuli (BH1) was declared 3.95mg/l by the laboratory.

3) Water quality of neaby shallow wells

Table 3.4.3 Water quality of shallow wells in Mpumbuli village

Well Type	Coordinate			Well Depth	F (mg/l)	pH	Conductivity (mS/m)	Distance from Drilled Point(km)
Shallow well	36M	0552846E	9413274N	7-8m	0.29	4.6	25.1	3.4 km
Shallow Well	36M	0552704E	9413386N	<20m	0.3	5.2	16	3.2 km

Electric conductivity values are 25.1(mS/m) and 16 (mS/m). Salinity is lower than drilled boreholes. Retention time of Shallow water may be shorter than deep water.

(3) Mabama Village (BH1)

1) Site works / Geology

Unconsolidated sediments lie above 18m depth. 18-21m is a highly weathered gneiss zone and slight weathered or fresh gneiss is distributed below 21m. Weathered gneiss around 21-31m involves clay fractured and oxidized. But there is no water coming. 38 – 58m is rarely fractured fresh gneiss. The First water strike was 59m depth and the water yield increased drastically. It is fractured gneiss without oxidation. The Water yield at 61m was 6.6 m^3/h, at 79m was 11 m^3/h.

The major fracture involving plenty of water was not oxidized. ORP values of the water below 61m depth are -14mV – 7mV. These facts indicate that the major aquifer is under a highly reductive environment.

Below 20m, SP logging curve shows that a gradual positive shift consistent with ORP which increases gradually.

See the Data Book E.9 and E.25 for the detailed description.

2) Water quality

Figure 3.4.7 shows the water quality change through site works.

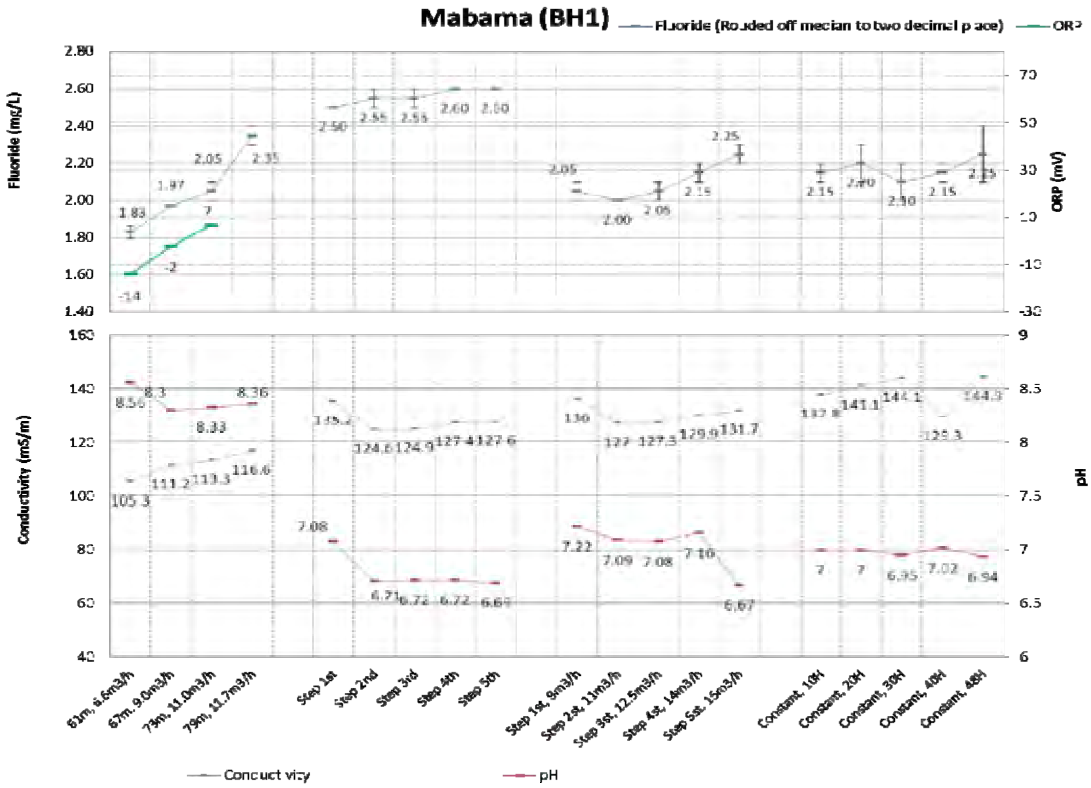

Figure 3.4.7 Water quality change through site works in Mabama village (BH1)

3）Water quality of neighboring wells

Table 3.4.4 Water quality of wells in Mabama village

Well Type	Coordinate			Well Depth	F (mg/l)	pH	Cond. (mS/m)	Dist. from Drilled Point BH1
NPW	36M	0447574	9434083	N/A	0.185-0.187	5.73	9.00	0.7 km
DW HP 1	36M	0447443	9434070	N/A	0.47-0.48	6.01	76.0	0.8 km
DW HP 2	36M	0448057	9432295	N/A	0.25-0.26	6.05	7.24	1.7 km
DW HP 3	36M	0449672	9430063	N/A	0.12-0.14	5.64	11.02	4.2 km
DW HP 4	36M	0445374	9435000	N/A	1.00-1.01	6.50	174.8	3.0 km

NPW=Non Protected Well. DW HP＝Deep Well Hand Pump

(4) Mabama Village (BH2)

1) Site works / Geology

The first water strike was is around 30m and water increased up to 1.3 m^3/h. But the yield decreased gradually. The Pumping test result shows that water yield is 0.8 m^3/h.

The Rock type is granitic gneiss. And its fracture is not oxidized the same as Mabama Village (BH1).

See the Data Book E.10 and E.26 for the detailed description.

2) Water quality

Figure 3.4.8 shows the water quality change through site works.

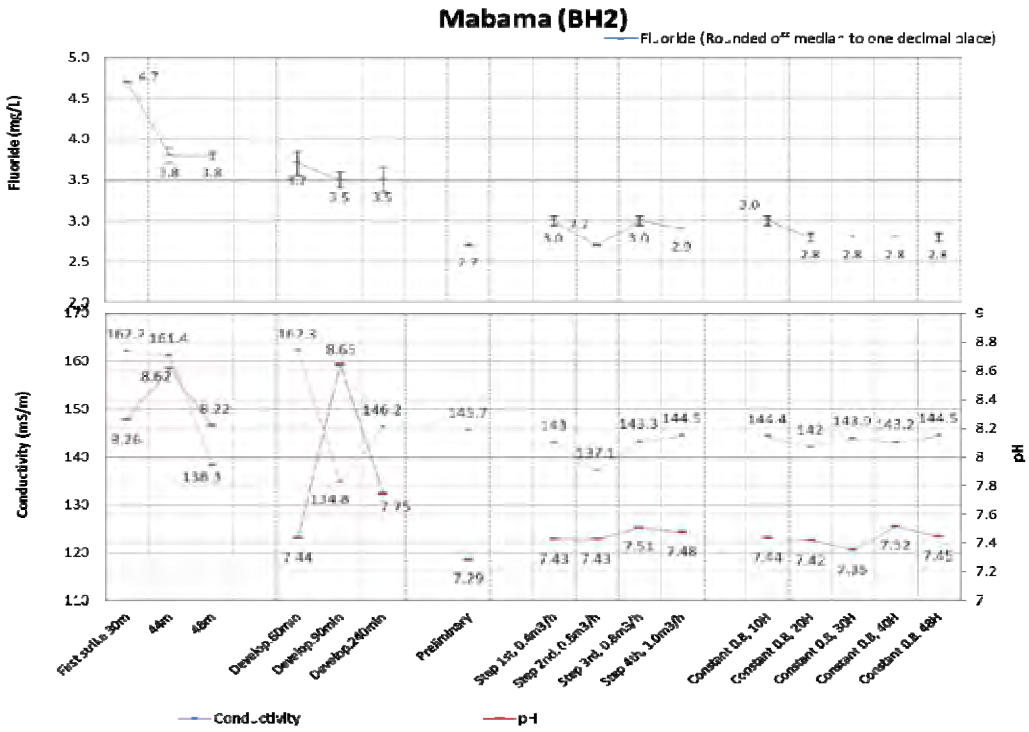

Figure 3.4.8 Water quality change through site works in Mabama (BH2)

(5) Mabama Village (BH3)

1) Site works / Geology

There is no water around the boundary between unconsolidated sediments and basement rock. A little water came from 20m depth. But at the end of the drilling, the yield was incapable of measurement and this borehole was declared negative.

A Water sample was taken during drilling. Its fluoride concentration is 3.1 – 3.2 mg/l.

See the Data Book E.11 for the detailed description.

Table 3.4.5 Water quality of Mabama village (BH3)

Sampling	Well Depth	F (mg/l)	pH	Conductivity (mS/m)
Drilling	86m	3.1 - 3.2	8.16	134.5

(6) Ufuluma Village (BH1)

Water yield was unknown because of incapable measurement. Only damp sand around 28-31m depth was recognized. The Target depth was above 60m depth based on a 2-dimension resistivity diagram. This borehole was declared negative.

Some slight fracture zones are recognized. But the cuttings were not oxidized. Its geological condition is very similar to Mabama Village boreholes.

See the Data Book E.12 for the detailed description.

3.4.4 TABORA MUNICIPALITY

(1) Kakola Village (BH1)

1) Site works / Geology

The first strike of water was at 22m depth though incapable of measuring yield. The water yield increased drastically at 30m depth which is the boundary between unconsolidated sediments and granitic rock. Below 30m the yield gradually increased.

Granitic rock and schist like rock are discharged from the borehole cyclically. But the relationship between those rocks is ambiguous. In general, there are some cases that it's difficult to distinguish pelitic schist from mafic or pelitic gneiss. Granitic rock is reddish pink colored, biotite scattered and consist of mainly course quartz crystal.

Above 55m is a granitic rock rich zone and below 55m is a schist like rock rich zone.

If this cyclic distribution were caused by a fault, the fault is extremely large, though large crushed zone was not recognized. A possibility that the granitic rock intruded into the schist is not denied, although any hornfels facies was not observed. These facts imply that the rock is pegmatite made by partial melting of metamorphic rock like schist. It may be originally sedimentary rock like alternation of sand and mud.

The horizons more than 4cps of gamma rays correspond to water coming from a fracture. It may indicate the clay mineral was generated along with fracturing. Cuttings of the fracture zone involve a little clay.

The SP logging curve shows a negative shift around 100m depth. Oxygen Reduction Potential (ORP) of discharged water below 96m depth shows a negative value compared to above 96m. Negative shift of SP logging indicates influx of reductive ground water.

See the Data Book E.13 and E.27 for the detailed description.

2) Water quality

The concentration of Fluoride diminished obviously between 31m and 49m, and between 78m and 82m. ORP increased between 36 – 49m, 54 – 60m, 82 – 84m, 96 – 102. But as a whole, it decreased gradually along the works as a whole. A scatter graph of ORP and Fluoride shows 3 groups. It indicates that groundwater possibly consists of at least 3 water masses of 30-46m, 49-78m, 82-108m. See the Figure 3.4.9 and 3.4.10.

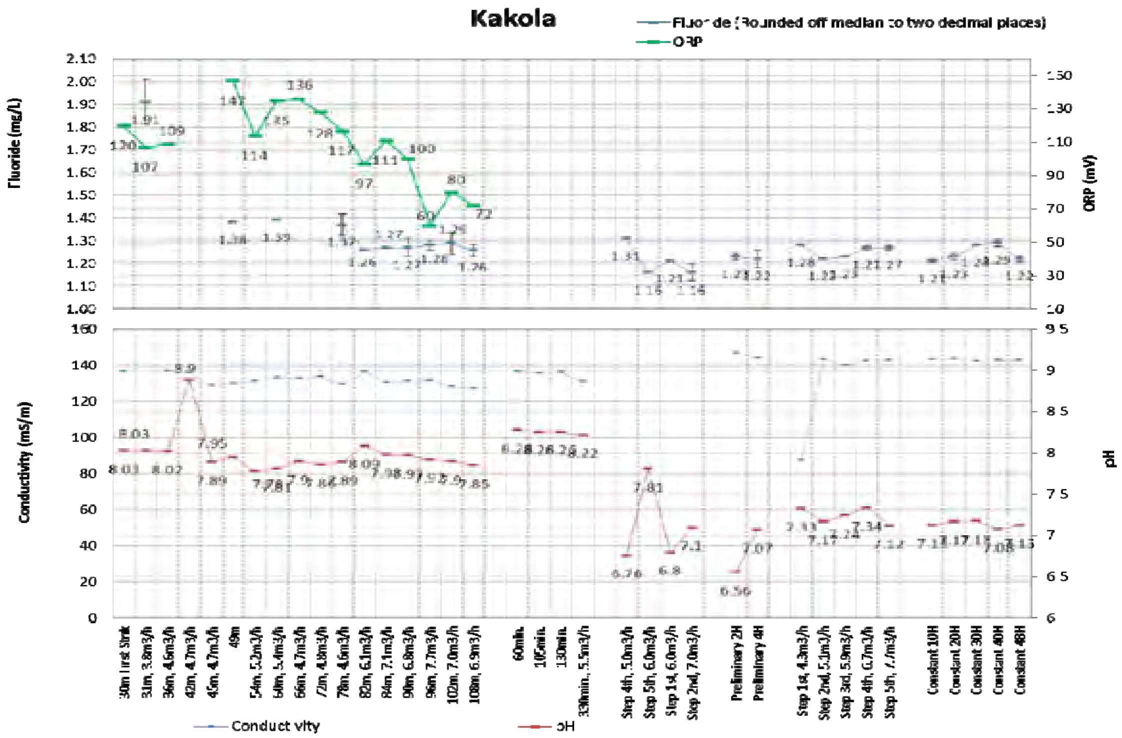

Figure 3.4.9 Water quality change through site works in Kakola village (BH1)

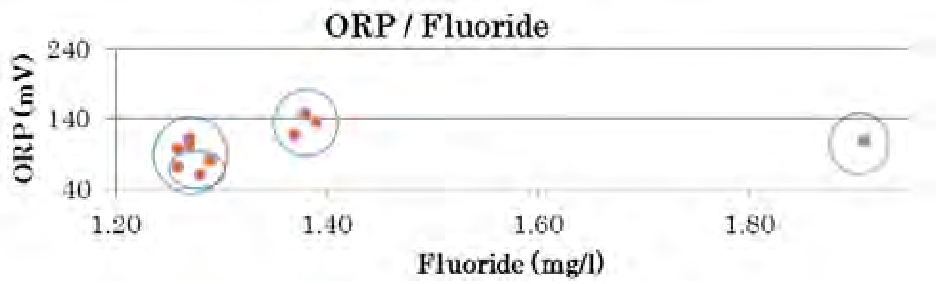

Figure 3.4.10 Scatter graph of ORP and Fluoride during drilling works

3.4.5 IGUNGA DISTRICT

(1) Igumo Village（BH1）

1) Site works / Geology

Gneiss was distributed below 4m depth through the borehole. The borehole yielded 15 m^3/h water which came from 38 to 74m depth.

The water taken at the end of drilling (80m depth) contains fluoride 4mg/l although the water at 36m depth contains more than 4.9mg/l of fluoride. It implies that the fluoride concentration of the deep aquifer may be relatively low. SP negative spike around 40m and 53m depth may indicate an influx of reductive water. Therefore major fractures exist around 40m and 53m. The measuring of water yield shows the possibility of existence of minor fractures. For that reason, the casing screen was set at 66.2-72.1m and sealed above 62m in anticipation that the fluoride concentration decreases down to below 4.0mg/l. But the pumping test showed the maximum discharge rate was 1.0 m^3/l. And what is worse, fluoride concentration did not show any decrease. As a reason for this result, the mistake of water yield measuring or water sample collection during drilling works can be mentioned. See the Data Book E.14 and E.28 for the detailed description.

2) Water quality

Figure 3.4.11 shows the water quality change through site works.

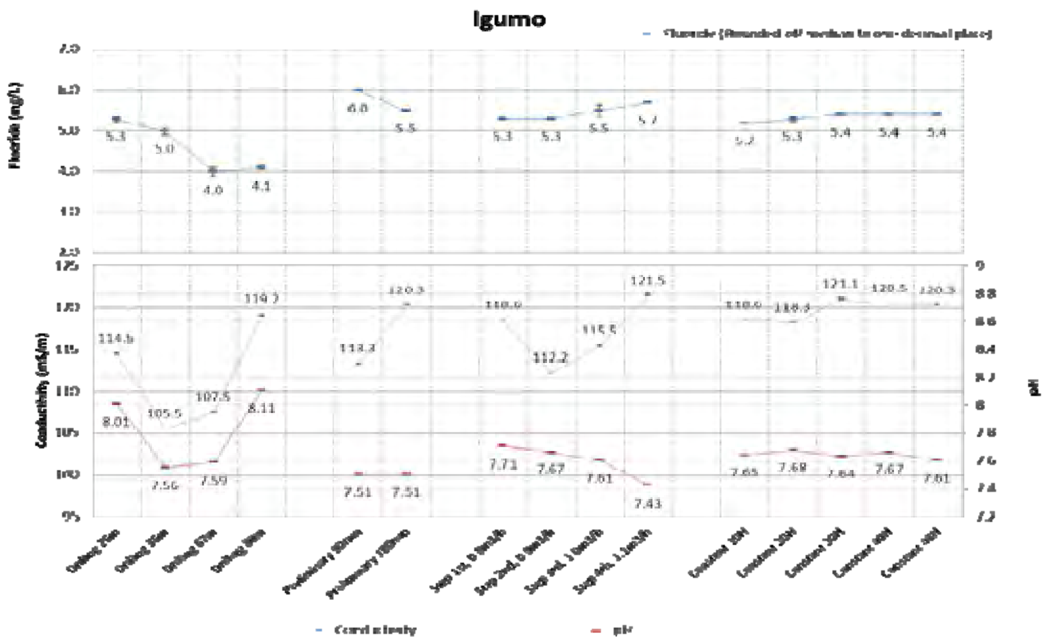

Figure 3.4.11 Water quality change through site works in Igumo Village BH1

3) Water quality nearby water well

Table3.4.6 Water quality of shallow water in Igumo Village

Well Type	Coordinate			Well Depth(m)	F (mg/l)	pH	Cond. (mS/m)	Dist. from Drilled Point(km)
HP SW	36M	0551674	94993828	2	0.19 – 0.20	6.2	15.2	1.9 km

HP SW＝Hand pump Shallow well

(2) Buhekela Village（BH1）

Gneiss was distributed below 2m depth through the borehole. A little water appeared at around 44m depth. But water yield disappeared immediately. It might be patched water. Although there are fractures above 30m depth and 36-39m, the borehole did not yield enough water and was declared negative.

Geophysical logging was carried out after filling up the borehole by poured water. Resistivity shows very low value less than 150Ω-m. We re-measured after changing the electrode position and got the same result. It's not sure what caused the low resistivity value. The resistivity curve is consistent with penetration rate and may indicate if fractures are concentrated.

See the Data Book E.15 for the detailed description.

(3) Kagongwa（BH1）

Semi-consolidated muddy sand layer lies above the 25m depth. Gneiss was distributed below the 25m depth. There was no water and it was declared negative. A pumping test and water quality analysis could not be carried out.

Logging was carried out after poured water. The negative shift of resistivity is consistent with an oxidized fracture zone. Fractures certainly exist. Poured water may penetrate into fractures to generate flow potential. Probably that is the reason why the SP curve shows a negative shift although it's dry borehole.

See the Data Book E.16 for the detailed description.

3.5 DISCUSSION

3.5.1 ROCK DISTRIBUTION

Major rocks recognized in this project are Gneiss and shale. Boreholes in the same village yielded the same type of rock.

The Existing geological map shows widespread distribution of granite. We recognized granite on surface outcrops. But major mineral composition in this project is not felsic rock but also mafic rock. It may be caused by the difference of weathering tolerance between mafic and felsic rocks. Namely mafic rock does not have strong weathering tolerance compared to felsic rock. And mafic rock was weathered and covered with clastic materials.

Table 3.5.1 Rock distribution

Rock	Village
Gray (Grayish white)－Black Gneiss	Mabama / Ufuluma / Buhekela
Pink (Dark Pink / Dark Red)－Black Gneiss	Usunga / Mpombwe / Kagongwa
Shale	Isanga
Hard Shale	Mpumbuli
Migmatite	Kakola

3.5.2 Water Quality Difference among Sites

(1) Fluoride

Table 3.5.2 Outline of Fluoride change through works

Site name	Drilling	Step drawdown Pumping test	Constant rate test	Fluoride (mg/l)	
				Laboratory	Nearby wells
Igumo (BH1)			(1.0 m3/h)	7.00	0.19 - 0.20
Isanga (BH1)			(3.7 m3/h)	2.40	9.3 - 9.5
Isanga (BH2)			(3.0 m3/h)	1.10	1.36 - 1.39
Mpombwe (BH2)			(0.1 m3/h)	1.10	N/A
Usunga (BH1)			(0.2 m3/h)	1.46	0.20 - 0.50
Usunga (BH2)			(0.8 m3/h)	2.53	
Kakola (BH1)			(6.0 m3/h)	1.61	N/A
Mpumbuli (BH2)			(9.0 m3/h)	3.95	0.29 - 0.30
Mabama (BH1)			(14.0 m3/h)	1.50	0.185 - 0.187
Mabama (BH2)			(0.8 m3/h)	2.24	

The Outline of fluoride concentration change through the works are shown in Table 3.5.2. Each borehole shows its own feature except for Isanga. Only two boreholes in Isanga village have similar change. It's caused by almost the same geological structure (borehole distance is only 120m).

Isanga shallow well shows the highest concentration of fluoride (9.3-9.5mg/l). All villages except Isanga village show that the fluoride concentration is lower than shallow wells. A High concentration of fluoride may be trapped in the soil of Isanga. It can be a source of fluoride solution. Although the shallow well has a high concentration of fluoride, hand dug pit water in a river shows 1.36-1.39mg/l. There is a complicated ground water mass structure in Isanga village.

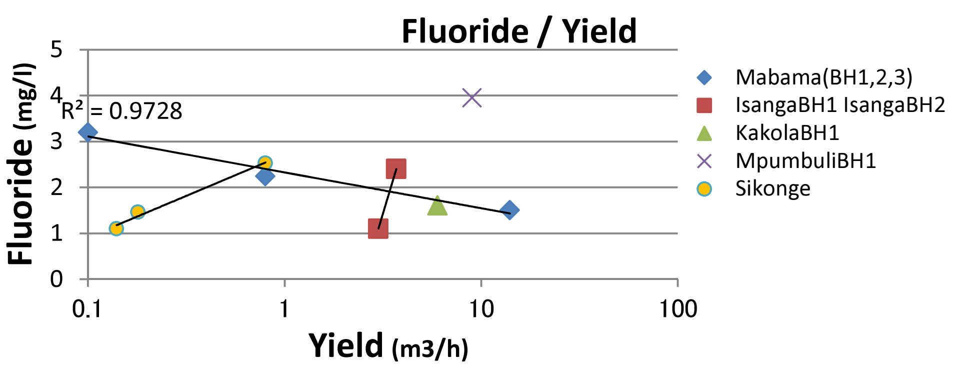

Figure 3.5.1 Scatter graph of water yield and Fluoride concentration

A Scatter diagram of water yield and fluoride (Figure 3.5.1) shows the following. In Isanga village and Sikonge district, the higher the water yield, the higher fluoride concentrations. As opposed to them, in Mabama village, the higher water yield, the lower fluoride concentrations.

In Mabama village, three boreholes (BH1(14 m^3/h ; F 1.5 mg/l)、BH2(0.8 m^3/h ; F 2.24 mg/l)、BH3(less than 0.2 m^3/h ; F 3.2 mg/l)) are on the same fault system and same rock type. It implies that those boreholes are in the same water mass system. One of main causes of the difference of yield is size of fracture zone namely permeability. The poorer fractures, the lower water yield. Water mass movement in low yield borehole is slower than high yield boreholes. And the time of contact between water and rock would be longer to elute more fluoride. The main source of fluoride in Mabama village is possibly the contacting rock in Mabama. Meanwhile in the other village, probably there are various main sources of fluoride.

(2) Self-potential (SP)

Flow potential and oxidation reduction potential (ORP) are main sources of self-potential concerning ground water. SP logging which is usually used to identify an aquifer can detect an SP anomaly between aquifer (sand, pebbles etc.) and aquiclude (clay etc.). The SP curve shows relative change caused by the anomaly. Meanwhile each logging curve has its own data range. The SP curve range is probably affected by ORP of ground water. Namely SP curve consist of ORP of ground water and geological SP anomaly (or any other source).

Figure 3.5.2 is a comparison of SP curve ranges among boreholes which has a water yield more than 0.72 m3/h (Boreholes that yield less than 0.72m3/h are poured water for logging after drilling. Those boreholes' SP range is not of ground water but poured water). Figure 3.5.2 includes also ORP data of Kakola (BH1) and Mabama (BH1).

ORP measuring shows that Mabama (BH1) ground water is in a more reductive environment than Kakola (BH1). SP logging range of Mabama (BH1) is lower than Kakola (BH1).

The SP ranges of Mabama Village boreholes (BH1, BH2) are lower than others. It probably indicates that Mabama Village ground water mass is in a reductive environment. The fact that those rock cuttings of fracture zones in Mabama boreholes are not oxidized is consistent with this interpretation. Recharged groundwater in Mabama village might move slower than other area.

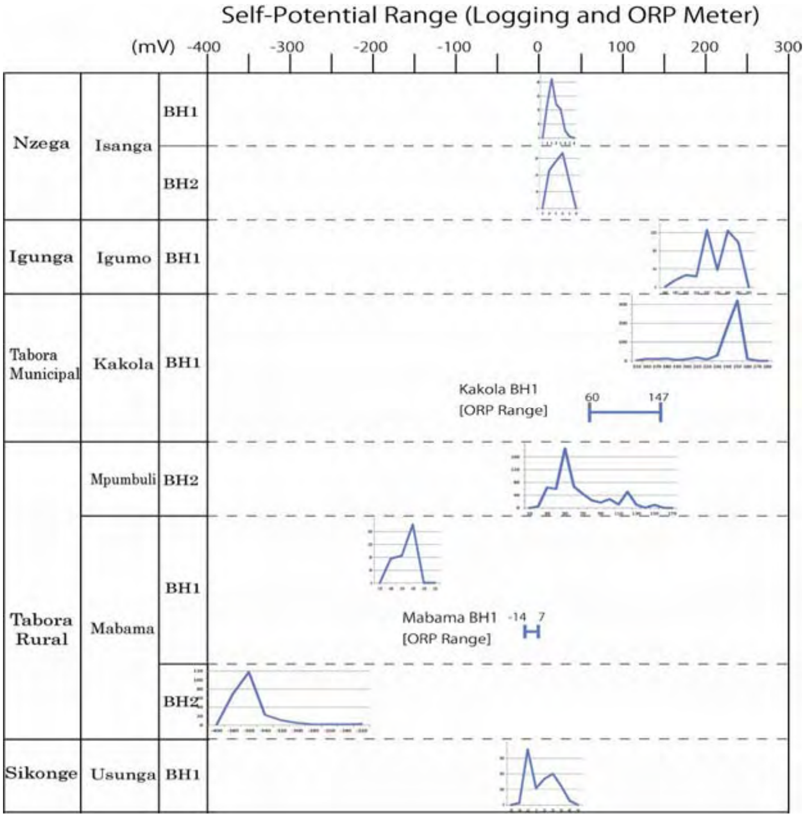

Figure 3.5.2 Comparison between SP ranges

A scatter diagram of the mode value of SP logging range and water yield shows 2 groups. One is Mabama Village and another is other villages. In each group, the SP mode value is positively correlated with water yield. There are highly fractured zones in those large yield boreholes. Groundwater flow supplies oxygen. The Large fracture zone probably retains oxidative environment compared to the minor fracture zone.

A Self-potential sounding method is used in some ground water investigation. The method might be able to detect a high water yield drilling point within the same geological area in Tabora region.

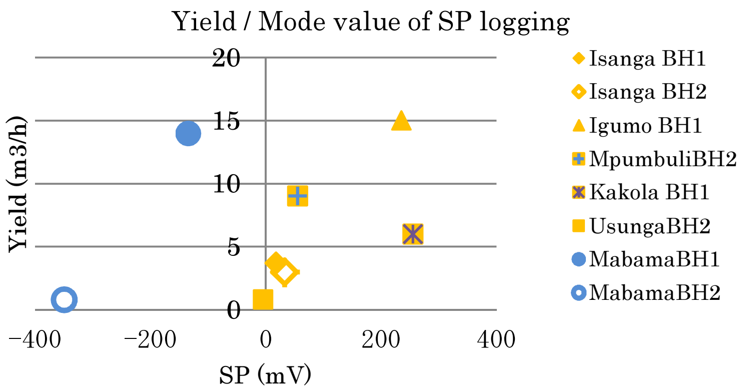

Figure 3.5.3 Scatter diagram of water yield and mode value of SP logging

3.5.3 Drilling

Summary of drilling result is shown in Table 3.5.3 and 3.5.4.

Table 3.5.3 Drilling Result

District	Village	Drilling No.	Pumping Test																									
			Step Draw Down Test																	Constant Rate Test						Recovery Test		Critical Yield
			Date	Starting Water Level	1st Step			2nd Step			3rd Step			4th Step			5th Step			Date(from)	Starting Water Level	Discharging Rate	Pumping Duration	Dynamic Water Level	Specific Capacity	Measuring Duration	Recovered Water Level	
					Discharging Rate	Pumping Duration	Dynamic Water Level	Discharging Rate	Pumping Duration	Dynamic Water Level	Discharging Rate	Pumping Duration	Dynamic Water Level	Discharging Rate	Pumping Duration	Dynamic Water Level	Discharging Rate	Pumping Duration	Dynamic Water Level									
				GL- m	m3/h	hours	GL- m	m3/h	hours	GL- m	m3/h	hours	GL- m	m3/h	hours	GL- m	m3/h	hours	GL- m		GL- m	m3/h	hours	GL- m	m3/h/m	hours	GL- m	m3/h
Nzega	Isanga	NZ-047BH1	2010/10/17	1.74	2.5	2	15.6	3	2	24.4	3.5	2	29.27	4	2	44.36	4.5	2	74.2	2010/10/17	2.82	3.7	48	63.55	0.061	48	2.05	3.7
		NZ-047BH2	2010/10/20	5.52	1.8	2	17.96	2.3	2	23.7	2.8	2	28.81	3.3	2	38.11	4	2	53.09	2010/10/20	6.64	3	48	42.98	0.083	24	6.17	3
Sikonge	Usunga	SK-028BH1	2010/10/11	55.01	0.2	1	71.94	0.3	0:40	87.78	–	–	–	–	–	–	–	–	–	2010/10/11	46.2	0.3	1:30	93.9	0.006	24	40.27	0.18
		SK-028BH2	2010/9/27	17.39	0.4	2	20.83	0.6	2	37.66	0.8	2	58.24	1	2	97.99	1.2	2	128.75	2010/9/28	17.24	0.8	48	117.29	0.008	24	17.51	0.8
	Mpombwe	SK-037BH1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		SK-037BH2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2010/10/15	59.21	0.3	2	85.95	0.011	26	62.84	0.14
Tabora Rural	Mpumbuli	TR-054BH1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		TR-054BH2	2010/10/6	33.04	5	2	52.46	6	2	61.1	7	2	73.82	8.2	2	86.95	9.8	2	107.69	2010/10/7	33.09	9	48	101.38	0.132	24	33.30	9
	Mabama	TR-069BH1	2010/9/22	5.93	9	2	25.38	11	2	36.3	12.5	2	47.21	14	2	55.12	15	2	67.53	2010/9/23	6.21	14	48	66.69	0.231	24	8.59	14
		TR-069BH2	2010/9/15	11.68	0.4	2	17.04	0.6	2	21.89	0.8	2	40.08	1	2	56.53	1.2	2	60.23	2010/9/16	11.2	0.8	48	60.2	0.016	16	11.06	0.8
		TR-069BH3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Ufuluma	TR-098BH1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tabora Urban Municipal	Kakola	TU-008BH1	2010/10/2	14.06	4.3	2	18.84	5.1	2	25.64	5.9	2	31.7	6.7	2	62.54	7.7	2	97.28	2010/9/23	14.35	6	48	87.78	0.082	24	14.37	6
Igunga	Igumo	IG-007BH1	2010/10/27	9.61	0.8	2	16.03	0.9	2	42.19	1	2	53.63	1.1	0.8	75.87	–	–	–	2010/10/27	9.82	1	48	49.03	0.025504	24	9.82	1
	Buhekela	IG-012BH1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Kagongwa	IG-033BH1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 3.5.4 Pumping Test Result

District	Village	Drilling No.	Coordinate			Registered No. of Tanzania	Drilling										
				X	Y		Date		Bit Type	Drilling Diameter	Drilling Depth	Yield at the end of Driling	Logging	PVC Depth (GL- m)	Screen Psition	Toltal Screen Length	Yield by AirLifting
							Start	Finish		inch	GL- m	m3/h	Date	GL- m		m	m3/h
Nzega	Isanga	NZ-047BH1	36M	0523911	9550830	672/2010	2010/9/24	2010/9/27	DTH	7-5/8″	85	3.3	2010/9/25	80.9	30.75-36.65,42.55-45.5,48.45-54.35,57.3-66.15,72.05-75	26.55	3.5
		NZ-047BH2	36M	0524030	9550844	673/2010	2010/9/27	2010/9/28	DTH	7-5/8″	80	2.7	2010/9/28	78	39.65-42.6,48.5-54.4,57.35-66.2,72.1-75.05	20.65	2.7
Sikonge	Usunga	SK-028BH1	36M	0492530	9368238	670/2010	2010/9/14	2010/9/17	DTH	7-5/8″	98	0.1-0.2?	2010/9/17	96	25.2-39.95,45.85-51.75,54.7-57.65,66.5-75.35,81.25-87.15,90.1-93.05	41.3	0.1-0.2
		SK-028BH2	36M	0494744	9368375	671/2010	2010/9/18	2010/9/22	DTH	7-5/8″	150	0.4		137.5	49-60.8,66.7-69.65,78.5-81.45,84.4-87.35,108-113.9,125.7-131.6	32.45	0.8
	Mpombwe	SK-037BH1	36M	0466529	9402556	–	2010/9/10	2010/9/11	DTH	7-5/8″	79	I.M.	–	–	–	–	–
		SK-037BH2	36M	0465785	9405719	669/2010	2010/9/12	2010/9/13	DTH	7-5/8″	92	0.1-0.2?	2010/9/13	91	20.2-23.15,29.05-32,40.85-46.75,52.65-55.6,58.55-61.5,67.4-76.25,79.2-88.05	35.4	0.1-0.2
Tabora Rural	Mpumbuli	TR-054BH1	36M	0549469	9413752	–	2010/8/17	2010/8/17	Air + Drag	7	50	0	–	–	–	–	–
		TR-054BH2	36M	0549535	9413742	662/2010	2010/8/18	2010/8/19	DTH	7-5/8″	130	7	2010/8/23	125	66.00-86.65, 92.55-107.30, 113.20-122.05	44.25	7
	Mabama	TR-069BH1	36M	0448218	9433981	664/2010	2010/9/1	2010/9/9	DTH	7-5/8″	79	11.7	2010/9/8	75.7	58.0-69.8	5.9	12
		TR-069BH2	36M	0448362	9433208	665/2010	2010/9/10	2010/9/13	DTH	7-5/8″	82	0.6	2010/9/12	63.7	31.25-34.2,37.15-46,51.9-54.85	17.7	0.8
		TR-069BH3	36M	0448517	9433250	–	2010/9/14	2010/9/16	DTH	7-5/8″	86	I.M.	2010/9/16	–	–	–	–
	Ufuluma	TR-098BH1	36M	0432350	9447793	–	2010/9/19	2010/9/22	DTH	7-5/8″	86	I.M.	2010/9/22	–	–	–	–
Tabora Urban Municipal	Kakola	TU-008BH1	36M	0482083	9462843	663/2010	2010/8/26	2010/8/31	DTH	7-5/8″	108	6.9	2010/8/29	102	28.25-45.95,48.9-54.8,60.7-69.55,78.4-84.3,87.25-96.1	47.2	5.8
Igunga	Igumo	IG-007BH1	36M	0551014	9495593	675/2010	2010/9/24	2010/9/28	DTH	7-5/8″	80	15.4	2010/9/27	78	66.2-72.1	5.1	1
	Buhekela	IG-012BH1	36M	0578471	9472418	–	2010/9/29	2010/10/6	DTH	7-5/8″	70	0	2010/10/6	–	–	–	–
	Kagongwa	IG-033BH1	36M	0573228	9553481	–	2010/9/29	2010/10/1	DTH	7-5/8″	82	0	2010/10/1	–	–	–	–

I.M. = Incapable Measurement

(1) Drilling Depth

The Drilling depth of the successful borehole in Usunga village is 150m. It is extremely deep compared to other successes. Deeper drilling is necessary to get water in Sikonge district. It's better to divide Tabora region into two areas based on drilling depth (Table 3.5.5).

In area A, the average drilling depth of successful boreholes is 92m. The Average drilling depth of all area A boreholes is 85m. The Recommended average drilling depth is 90m for the drilling project.

In area B, successful drilling was only one, 150m drilling depth. The Fracture in Sikonge region is very thin. So it's necessary to drill deeper than other area to scoop up whole water in the borehole. The Recommended drilling depth is 150m in Sikonge region.

Table 3.5.5 Drilling Depth

Area		Drilling depth (m)			Recommended Drilling depth（m）
A	Nzega, Igunga, Tabora Municipality, Tabora Rural	All borehole	Maximum	130	90m
			Minimum	50	
			Average	85	
		Success	Maximum	130	
			Minimum	79	
			Average	92	
B	Sikonge	All borehole	Maximum	150	150m
			Minimum	79	
			Average	105	
		Success		150	

(2) Success rate

To calculate the success rate, we tentatively define 0.72m^3/h as the minimum discharge rate to be successful.

A success rate calculated on all borehole results is 50% without water quality.

The Final success rate is 44% after water quality analysis.

Table 3.5.6 Result of pumping test and water quality analysis (Fluoride)

Pumping Test	0 m^3/h	4	25%
	0<・<0.72 m^3/h	4	25%
	0.72≦ m^3/h	8	50%
Fluoride (11 samples)	≦1.5	4	36%
	1.5<・≦4.0 mg/l	6	55%
	4.0< mg/l	1	9%
Total	Drilled borehole	16	44%
	Success	7	

Table 3.5.7 Success rate of pumping test result

	Area	No. of pumping test site	> 0.72 m^3/h	Success rate
Pumping Test	Nzega, Igunga, Tabora Municipality, Tabora Rural, Sikonge	10	8	80%

Table 3.5.8 Success rate by area

Area	District	No	Yield			Fluoride			Rate to no. of sites	
			Yield (m^3/h)	No.	Rate	Concentration (mg/l)	No.	Rate		
A	Nzega, Igunga, Tabora Municipality, Tabora Rural <12 sites >	12	0	3	25%	≦1.5	2	33%	17%	50 %
			0<・<0.72	2	17%	1.5<・≦4.0	4	57%	33%	
			0.72 ≦	7	58%	4.0 <	1	17%	8%	
B	Sikonge < 4 sites >	4	0	1	25%	≦1.5	0	0%	0%	
			0<・<0.72	2	50%	1.5<・≦4.0	1	100%	25%	
			0.72 ≦	1	25%	4.0 <	0	0%	0%	

3.5.4 CONCLUSION

(1) Total 16 boreholes were drilled in 10 villages. 7 boreholes satisfied the yield (>0.72 m^3/h) and water quality standard. 5 boreholes are designated to be supplied for piping water supply system (Level 2) construction.

(2) The Success rate based on all boreholes is 44%. Area A (Nzega, Igunga, Tabora Urban Municipal, Tabora Rural) is 50%. Area B (Sikonge) is 25%.

(3) The Required drilling depth in Sikonge is deeper than the others. And the success rate is much lower than the others. The Difficulty of Sikonge area should be taken into account to plan drilling project in Tabora region.

(4) Various geological features are recognized in this project. Each site has its own water quality change curve. The ground water in Mabama village is probably in a reductive environment based on self-potential, Fluoride, and water yield.

(5) Self-potential probably relates to water yield based on SP logging and ORP measuring.

(6) A 2 Dimension resistivity diagram reflected the actual geological structure very well (see Geophysical survey chapter). The Success rate of drilling must advance by feedback of this project data.

(7) The Geological condition in Tabora region is complicated. Boreholes in this project possibly represent regional geological feature. This test well drilling was a meaningful survey.

CHAPTER 4 HANDPUMP REPAIRING

4.1 GENERAL

4.1.1 INTRODUCTION

Existing broken handpumps which could be repaired in light duty were repaired in this project. The repairing team instructed the handpump structure and how to maintain it to representatives of user. Target breakdown handpumps were picked from the list made in the 1st year of this project. Target handpump types are TANIRA and AFRIDEV.

The number of pumps is 4 pumps in the Igunga District, 23 pumps in the Nzega District, 5 pumps in the Sikonge District, 2 pumps in the Tabora Rural District, 1 pump in the Tabora Municipality, 11 pumps in the Urambo District, a total 46 pumps in the Tabora Region.

4.1.2 WORK SUMMARY

(1) Target

The target is a total number of 46 existing broken handpumps which could be repaired in light duty in 5 districts and 1 city. Handpump types are TANIRA and AFRIDEV. The table 4.4.1 shows the list of the repaired handpumps.

(2) Work Period

Repairing work started on 29/July/2010 and completed inspection on 21/October/2010.

Table 4.1.1 Repaired handpump list

No.	District/Municipality	HP Code	Ward No.	Ward	Village No.	Village/Street	Sub-V. No.	Sub-Village/Street	Location	Handpump No. in village	GPS Coordinates (Arc 1960) Lon	Lat	Type of Water Source	Type of Handpump	Water level	Well depth	Actual pump parts replaced	Actual concrete repairing
1	Igunga	IgVS-014HP-08	4	Igoweko	14	Uswaya	85	Mwakadele	Kamata	8	4.70404	33.51950	Deep well	Afridev	2	15	4 bearing bush,4 Bolt&Nuts, 1 Fulcram pin, 1 cup u seal, 1 o-ring, 2 riser main 3m	Cracked slab repaired
2	Igunga	IgVS-016HP-04	5	Igunga	16	Igunga Small Township	103	Stoo ya Pamba	Market	4	4.27874	33.87538	Deep well	Afridev	6	19	4 bearing bush,4 Bolt&Nuts, 1 Fulcram pin, 1 cup u seal, 1 o-ring, 1 flapper rubber	damaged apron and cracked cover repaired
3	Igunga	IgVS-055HP-03	16	Mwisi	55	Busomeke	378	Kati	Kaluma	3	4.52631	33.46684	Shallow well	TANIRA	1.2	4.2	handle pump 1pc, shock absorber 1pc, riser/rod 1.0m 1pc	well cver repaired
4	Igunga	IgVs-064HP-01	18	Ndembez	64	Moyofuke	440	Shelui	Mr. Yohadna Mishoro	1	4.33268	33.53714	Deep well	Afridev	3	12	4 bearing bush, 1 Cup u seal, 1 o-ring,1 foot valve receiver,1 fulcrum pin, rope 100m	damaged apron repaired
5	Nzega	NZVS-006HP-03	3	Igusule	6	Sojo	40	Nseme	NSEME	3	3.93916	32.86778	Deep well	Afridev	6.5	52	Bearing bush 8pc, flapper rubber 1pc,cup u seal 1pc, plunger ring assembly and o-ring 1pc	Nil
6	Nzega	NZVS-006HP-04	3	Igusule	6	Sojo	36	Bombani	BOMBANI	4	3.95529	32.86791	Deep well	Afridev	11	50	Bearing bush 4pc, flapper rubber 1pc,cup u seal 1pc, plunger ring assembly and 0-ring 1pc	Nil
7	Nzega	NZVS-006HP-05	3	Igusule	6	Sojo	36	Bombani	BOMBANI	5	3.96676	32.86699	Deep well	Afridev	11	59	Bearing bush 4pc, flapper rubber 1pc, cup u seal 1pc and plunger assembly	Nil
8	Nzega	NZVS-006HP-08	3	Igusule	6	Sojo	39	Ngogoto	NGOGOTO	8	3.98578	32.85896	Deep well	Afridev	48	70	Bearing bush 4pc, cylinder, flapper rubber 1pc, riser main 3m 8pc, rope 100m, o-ring, rod centrollizer 4pc and cup u seal 1pc	damaged apron repaired
9	Nzega	NZVS-014HP-12	5	Ikindwa	14	Kayombo	97	Matale	Matale	12	4.14980	32.89951	Shallow well	Tanira	1.5	3.5	Shock absober 1pc and sleeve bearing 1pc	damaged apron repaired
10	Nzega	NZVS-015HP-03	5	Ikindwa	15	Malolo	107	Malolo	Malolo	3	4.09841	32.86539	Shallow well	Tanira	1.5	3.6	Shock absober 1pc, sleeve bearing 1pc and plunger ring 1pc	damaged apron repaired
11	Nzega	NZVS-015HP-05	5	Ikindwa	15	Malolo	105	Kilyaloha	Kilyalyoma	5	4.08799	32.89006	Shallow well	Tanira	0,75	4.5	Hexagon screws 4pc, nuts 4pc shock absorber 1pc, sleeve bearing 1pv and plunger ring 1pc	Well cover and apron constructed
12	Nzega	NZVS-027HP-03	8	Itobo	27	Itobo	181	Nyasuli	NYASULI	3	4.17673	33.03605	Shallow well	Tanira	4.5	7	Cylinder complete, rods 1m,2m,3m, riser main 1pc, hexagon screws 4pc, nuts 4pc, sleve bearing 1pc and shock absorber 1pc	damaged apron and cover repaired
13	Nzega	NZVS-035HP-05	10	Kahama Nhalanga	35	Nhabala	251	Nhabala	Nhabala	5	4.13915	32.69303	Shallow well	Tanira	3	8.6	Cylinder complete, shock absober 1pc, sleeve bearing 1pc and plunger ring 1pc	damaged apron repaired and inspection cape provided
14	Nzega	NZVS-040HP-10	12	Kasela	40	Kasela	283	Njuka	NJUKA 2	10	4.09170	32.99449	Shallow well	Tanira	1	3.6	Shock absober 1pc, sleeve bearing 1pc and plunger ring 1pc	damaged apron and cover repaired
15	Nzega	NZVS-046HP-02	13	Lusu	46	Ifumba	307	Ifumba	KALEMANI	2	3.99056	33.23083	Unknown	Afridev	8.4	58	Bearing bush 8pc, flapper rubber 1pc, o-ring 1pc, riser main 1pc, rod 3m 2pc and cylinder assembly	Nil
16	Nzega	NZVS-047HP-01	13	Lusu	47	Isanga (Kipya)	310	Iponyamadumu	MLIMANI	1	4.05403	33.19281	Shallow well	Afridev	6	58	Bearing bush 8pc, flapper rubber 1pc, riser main 10pc, rod 3m 1pc, o-ring, cylinder complete, nuts 4pc and rope 120m	damaged apron repaired
17	Nzega	NZVS-049HP-03	13	Lusu	49	Mwaluzwilo	318	Bujinja	UNKNOWN	3	4.01515	33.20607	Deep well	Afridev	25	53	O-ring 1pc, cup u seal 1pc bearing bush 4pc and flapper rubber 1pc	Nil
18	Nzega	NZVS-054HP-05	14	Magengati	54	Magengati	349	Chang' Ombe	Chang'ombe	5	4.81128	33.05738	Shallow well	Tanira	1.5	3.3	Plunger ring1pc, riser coupline 1pc and hexagon screws 4pc	Nil
19	Nzega	NZVS-064HP-05	16	Mbogwe	64	Mbogwe	406	Mwangongo	MWANGONGO	5	4.13956	33.25614	Deep well	Afridev	12	50	Bearing bush 4pc, flapper rubber 1pc, o-ring, cup u seal 1pc and rod centrollizer 7pc	Nil
20	Nzega	NZVS-065HP-02	16	Mbogwe	65	Nhobola	411	Misana	MISAdna	2	4.11265	33.28784	Deep well	Afridev	6	34	O-ring 1pc, cup u seal 1pc and bearing bush 8pc	Nil
21	Nzega	NZVS-083HP-01	20	Mogwa	83	Usalala	520	King' Wangoko	KINGWANGOKO	1	4.25669	32.80421	Shallow well	Tanira	2	3.6	pump stand, sleeve bearing shock absorberand hexagon screws 4pc	damaged apron repaired and inspection cape provided
22	Nzega	NZVS-085HP-02	21	Muhugi	85	Ubinga	544	Ubinga	UBINGA	2	4.41341	33.30730	Shallow well	Tanira			Shorck absober1pc Sleeve bearing 1pc Raiser main 1m 1pc	damaged apron repaired
23	Nzega	NZVS-105HP-08	25	Nata	105	Kabale	676	Kasela	KASELA	8	4.05619	33.17280	Deep well	Afridev	10	58	Bearing bush 4pc, flapper rubber 1pc, o-ring 1pc, cup u seal 1pc and bolt&nuts 12x30mm	Nil
24	Nzega	NZVS-109HP-01	25	Nata	109	Nata	702	Nyalaja	dnaTA SHULENI	1	4.02965	33.13224	Shallow well	Afridev	22	34	Bearing bush 4pc, flapper rubber 1pc, o-ring 1pc, U seal 1pc foot valve and fulcrum pin 1pc	damaged apron repaired
25	Nzega	NZVS-147HP-04	36	Utwigu	147	Mwanhala	969	Mwanhala 'B'	UK	4	4.37594	33.14026	Shallow well	Tanira	2	4	Shock absober 1pc, sleeve bearing 1pc, hexagon screws and cylinder complete	damage apron and cover repaired
26	Nzega	NZVS-152HP-01	37	Wela	152	Mwansambo	995	Mwansambo 'A'	MWANSAMBO A	1	4.06328	33.34555	Shallow well	Tanira	2	5	pump handle assembly, cylinder 1.5m and riser/rod 3m 1pc, rod 1.5m 1pc	damage apron and cover repaired
27	Nzega	NZVS-153HP-03	37	Wela	153	Wela	1000	Kityelo	KITYELO	3	4.14258	33.29978	Shallow well	Afridev	7.8	62	U sael 1pc, o-ring 1pc, bearing bush 8pc and flapper rubber 1pc	Nil
28	Sikonge	SkVS-002HP-01	1	Chabutwa	2	Kabanga	3	Chang'ombe	Mzumia	1	5.79092	32.79138	Shallow well	Tanira	1.5	4.5	Shock absorber 1pc, sleeve bearing 1pc, plunger ring 1pc, gasket, punger ring 1pc, bottom valve 1pc, bottom valve body and handle nipple	Well cover provided with inspection cape
29	Sikonge	SkVS-004HP-03	1	Chabutwa	4	Kipanga Milimani	10	Kipanga Kati	Barahani	3	5.70512	32.82202	Shallow well	Tanira	2	4.7	Sleeve bearing 1pc, shock absorber 1pc, complete cylinder, Nuts M12 4pc	Well cover and apron repaired
30	Sikonge	SkVS-008HP-01	2	Igigwa	8	Lufwisi	32	Lufwisi	Juma Saidi	1	5.51670	32.80321	Shallow well	Tanira	1.5	4.7	Shock absorber 1pc, sleeve bearing 1pc, cast in pedestal, socket head hex screws 4pc and 1mriser/rod 1pc	Provision of cast in pedstal
31	Sikonge	SkVS-019HP-01	4	Kiloleli	19	Mtakuja	73	Mtakuja	Kwa Abel	1	5.91202	32.92888	Shallow well	Tanira	2	4.7	Shock absorber 1pc, sleeve bearing 1pc, socket head hex screws 4pc and nuts 4pc	Well cover provided with inspection cape
32	Sikonge	SkVS-021HP-01	5	Kiloli	21	Mwitiko	79	Mwitiko	Kwa Musa	1	6.83329	33.36206	Shallow well	Tanira	1.5	4.5	Sleeve bearing 1pc, shock absorber 1pc, hexagon screws 4pc, pump rod 1pc, cylinder complete	Well cover provided with inspection cape
33	Tabora Rural	TrVS-070HP-03	11	Mabama	70	Maswanya	306	Maswanya Mashariki	Shuleni	3	5.06497	32.49199	Shallow well	Afridev	2	5	Bearing bush 4pc, o-ring 1pc, u seal 1pc, rod centrollizer 3pc, 3mriser main 3pc, foot valve, bolt&nuts 4pc and pump body	damaged apron repaired
34	Tabora Rural	TrVS-103HP-01	16	Upuge	103	Mhogwe	443	Mhogwe B	Michel Paul	1	4.87703	33.04002	Shallow well	Afridev	3	55	Bearing bush 4pc, o-ring 1pc, foot valve assembly, bolt&nuts 4pc plunger ring 1pc and U seal 1pc	damaged apron repaired
35	Tabora Urban	TuVS-018HP-03	6	Ndevelwa	18	Inala	76	Ibasa	RAMADHAN	3	5.12019	32.95776	Shallow well	Afridev	1.1	4.4	Bearing bush 1pc , flapper rubber 1pc fulcrum pin 1pc, pum rod 1pc, o-ring 1pc, U seal 1pc and foot valve	damaged apron and cover repaired
36	Urambo	UrVS-020HP-01	5	Kaliua	20	Ilindwanoni	77	Mtapenda	Ally Kayugilo	1	5.04001	31.70268	Deep well	Afridev	8	20	Pump handle , flupper rubber and cup u seal	Nil
37	Urambo	UrVS-029HP-02	7	Kashishi	29	Ilege	111	Shindeni	Juakali Luhaga	2	4.44465	32.28248	Deep well	Afridev	1.5	41	Bearing bush 4pc, riser/rod 4pc, rod centrollizer 3pc and socket joint 1pc	Apron repaired
38	Urambo	UrVS-041HP-01	8	Kazaroho	41	Kazaroho	167	Kazaroho Mashariki	Kasele	1	4.98919	31.85712	Deep well	Afridev	25	65	Bearing bush 4pc, O-ring 1pc, U seal 1pc, flapper rubber 1pc and rod centrollizer 7pc	Nil
39	Urambo	UrVS-050HP-05	10	Muungano	50	Kalemela A	204	Magharibi A	George	5	4.99158	32.04001	Shallow well	Afridev	10	15	Bearing bush 4pc, handle pump assembly, pump rod 3m, U seal 1pc and o-ring 1pc	Nil
40	Urambo	UrVS-052HP-05	10	Muungano	52	Muungano	215	Mtukula	Shaaban dnasoro	5	5.01121	32.15076	Deep well	Afridev	3	45	Bearing bush 4pc, O-ring 1pc, U seal 1pc, plunger assembly, Flapper rubber 1pc and bolt& nuts 3pc	Nil
41	Urambo	UrVS-052HP-06	10	Muungano	52	Muungano	214	Mtakuja B	Mtoni Vilali	6	5.02766	32.15095	Deep well	Afridev	12	46	Bearing bush 4pc, O-ring 1pc, U seal 1pc and foot valve 1pc	Nil
42	Urambo	UrVS-063HP-08	12	Songambele	63	Uyogo	268	Uyogo mashariki	Mzee Mbogo	8	4.91114	32.03369	Shallow well	Afridev	5	8.5	Bearing bush 4pc, O-ring 1pc, U seal 1pc, flapper rubber 1pc, handle assembly and rope 20m	Well cover and apron repaired
43	Urambo	UrVS-065HP-02	13	Ugunga	65	Tuombe Mungu	275	Kusini	Shuleni/Mwl Lowe	2	5.09018	31.70813	Deep well	Afridev	9.5	45	Bearing bush 4pc, O-ring 1pc, U seal 1pc, flapper rubber 1pc and rod centrollizer 3pc NOTE:handle pump 1pc was replaced by D/Council	Nil
44	Urambo	UrVS-086HP-02	18	Usinge	86	Kombe	367	Kombe Kaskazini	Wambao	2	5.05880	31.54194	Deep well	Afridev	5	31	Bearing bush 4pcCup u seal 1pc, o-ring 1pc, flapper rubber 1pc and cylinder pipe 1pc	Well cover and apron repaired
45	Urambo	UrVS-090HP-06	18	Usinge	90	Usinge	382	Majengo Tabora	H Mstapha	6	5.09648	31.30966	Shallow well	Tanira	3	7.6	shock absorber 1pc, sleeve bearing 1pc, plunger ring 1pc and cylinder complete	Well cover and apron repaired
46	Urambo	UrVS-090HP-02	18	Usinge	90	Usinge	390	Usinge Mashariki	Shuleni	2	5.09282	31.30641	Shallow well	Tanira	4	7.1	shock absorber 1pc and sleeve bearing 1pc	Well cover and apron repaired

4.2 CONTENTS

4.2.1 REPAIRING AND TRAINING

Persons who take training were chosen prior to the repairing works because maintenance training is executed concurrently with repairing works. The users could learn handpump structure, failed parts, how to maintain, what they should do when the pump get problems. Users assisted the repairing works which are not so danger in order to heighten an effect of the training through the works.

Inspection was carried out by study team members to confirm the handpump functions normaly.

(1) Select persons who take training

Persons who take training are chosen at first. The students are representative of users, mainly members of the water user group, water committee or school teachers.

(2) Explanation

Students are explained the work process in 15 minutes. The trainer supplied ball point pens and note books.

(3) Confirmation of causes of trouble

The repairing team confirmed causes of trouble. Students participated in a pull up pump if it was needed.

(4) Repairing and training

The repairing team repaired the pump with explanations about the pump structure and how to maintain it.

(5) Repairing of concrete pad

If the damage of concrete caused the pump trouble, it was repaired.

4.2.2 INSPECTION

After repairing works, those pumps are inspected by the study team members. See the Data Book.

4.3 SPARE PARTS

Spare parts which are mainly replaced are listed as follows.

4.3.1 TANIRA

Main spare parts of TANIRA which were used for 19 pumps and repaired concrete parts are listed in Table 4.3.1

Shock absorbers and Sleeve bearings wear out easily because they are moving parts which support the pump handle. Bolts which fix pump stands are lost frequently. The plunger part is also worn out easily because it has moving parts installed into borehole. The riser main and Rod are used not only for repairing but also extension of the pumping depth. The natural water levels of some boreholes were too deep to pump during the dry season before addition of a riser main and Rod.

Table 4.3.1 Spare parts for TANIRA 19 pumps

Replaced parts	No. of pumps	pcs	Percentage
Shock absorber	18	18 pcs	95%
Sleeve bearing	16	16 pcs	84%
Hex screws	8	29 pcs	42%
Rod	7	12.5m	37%
Cylinder	7	7 pcs	37%
Plunger ring	6	6 pcs	32%
Riser main	5	7m	26%
Nut	4	16 pcs	21%
Plunger ring assembly	2	2 sets	11%
Handle	1	1 pc	5%
Riser coupling	1	1 pc	5%
Cast in pedestal	1	1 pc	5%
Gasket	1	1 pc	5%
Pump handle assembly	1	1 pc	5%
Pump stand	1	1set	5%
Concrete pad			
Well cover	14		74%
Apron repair	12		63%
Inspection cape	4		21%

4.3.2 AFRIDEV

Main spare parts of AFRIDEV which were used for 27 pumps and the repaired concrete parts are listed in Table 4.3.2

The Bearing Bush is worn out easily because it is made of plastic and supports a moving handle. If it is not replaced after being worn out, the Fulcram pin also will be worn out. The Bearing Bush should be replaced immediately after wearing out. O-ring and Cup u-seal are made of rubber for sealing, so are worn out easily. The Riser main and Rod are used not only for repairing but also extension of the pumping depth. The natural water level of some boreholes was too deep to pump during the dry season before addition of a Riser main and Rod.

Table 4.3.2 Spare parts for AFRIDEV 27 pumps

Replaced parts	No. of pumps	pcs	Percentage
Bearing bush	26	26 sets	96%
O-ring	24	24pcs	89%
Cup u seal	23	23pcs	85%
Flapper rubber	19	19pcs	70%
Bolt&Nuts	6	23pcs	22%
Rod centrallizer	6	27pcs	22%
Fulcram pin	5	5pcs	19%
Riser main	5	50m	19%
Rope	4	340m	15%
Rod	4	15m	15%
Cylinder	3	3sets	11%
Foot valve	3	3pcs	11%
Handle pump	3	3pcs	11%
Foot valve receiver	2	5pcs	7%
Plunger ring	2	2pcs	7%
Cylinder pipe	1	1pc	4%
Handle assembly	1	1pc	4%
Plunger ring assembly	1	1pc	4%
Plunger ring assembly and o-ring	1	1pc	4%
Pump body	1	1pc	4%
Socket joint	1	1pc	4%
Concrete			
Apron repair	12		45%
Well cover repair	4		15%

4.4 CAUSE OF THE NEGLECT OF BROKEN HANDPUMP

All handpumps were neglected when they had been out of order without any repairing work.

The factors which caused the neglect of broken handpumps are discussed as follows based on interviews of users or observations through this repairing work.

4.4.1 DIRECT FACTORS

Direct factors are follows.

- Users can not procure spare parts or a repairing technician.
- Users cannot be bothered paying for repair work
- Users were not instructed how to properly maintain pumps.

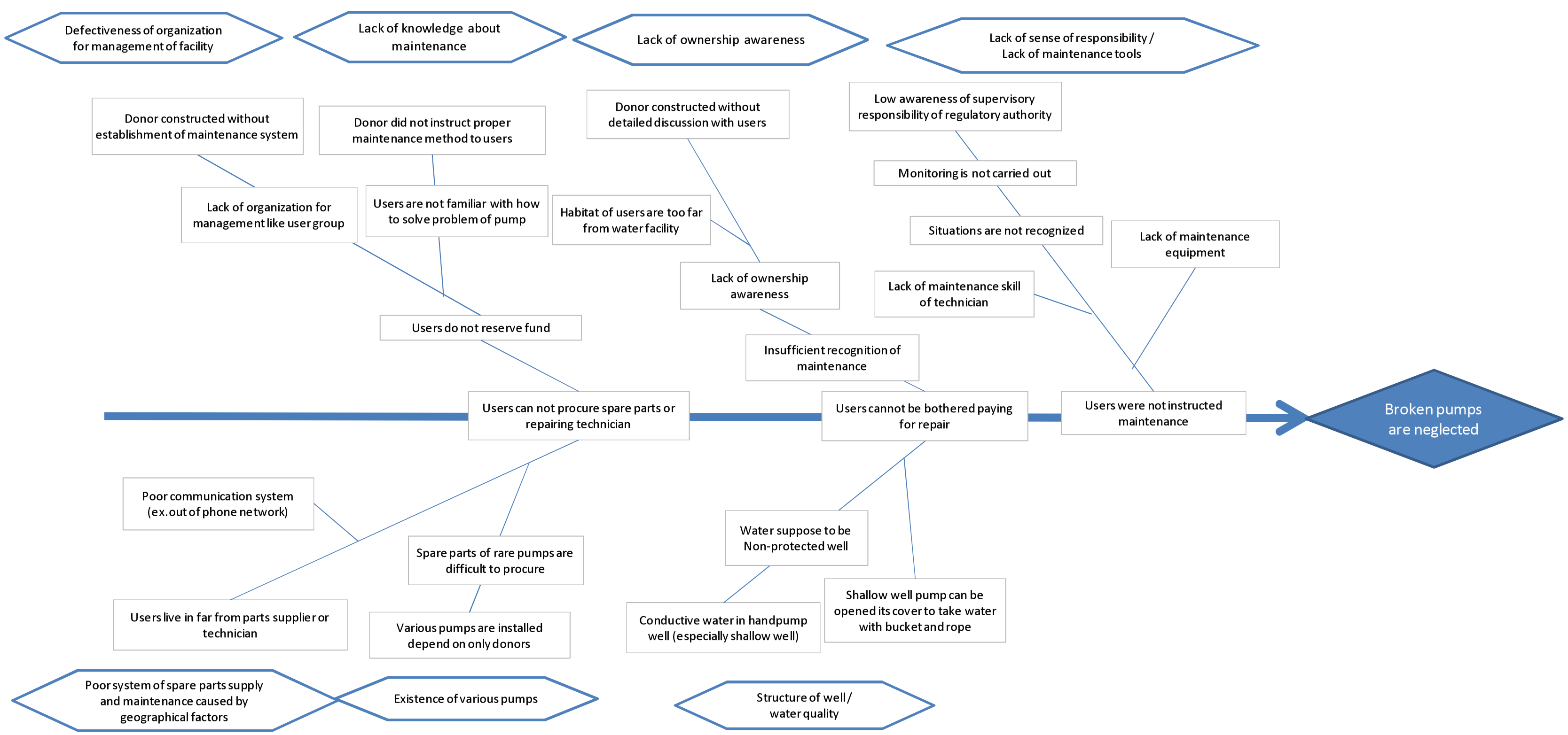

Figure 4.4.1 Fishbone diagram regarding neglect of broken handpump

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4.4.2 BACKGROUND OF DIRECT FACTORS

Those direct factors mentioned above have a back ground. The background can be categorized into 7 elements.

(1) Defectiveness of organization for management of facility

The donor did not establish a management system of the facility. User can not reserve funds systematically and can not pay for repair.

Proper training at the time of new construction should be carried out. Regulatory authority should instruct how to maintain existing facility.

(2) Lack of knowledge about maintenance

Because the donor did not carry out instruction about maintenance properly, the user doesn't have enough knowledge.

Because the donor constructed the facilities without proper maintenance training for users, they do not know how to solve any problems. That is the reason why users don't deposit money or they cannot repair it even if they have the money.

Proper training at the time of new construction should be carried out. The regulatory authority should instruct the maintain to owner of the existing facility to its users.

(3) Lack of ownership awareness

Because the donor constructed the site without detailed discussion with users or constructed it far from habitation, users lack ownership awareness. That is the reason why users cannot be bothered repairing by paying money.

The donor or regulatory authority should have a meeting with users at the time of new construction to develop the ownership awareness of the users. The regulatory authority should instruct how to maintain existing facility.

(4) Lack of sense of responsibility / lack of maintenance tools in the regulatory authority

Because most regulatory authorities do not have a good sense of responsibility, they are not familiar with current facility conditions, the technicians do not polish up their knowledge and techniques or come short in maintenance materials.

The regulatory authority should develop their sense of responsibility.

(5) Poor system of spare parts supply and maintenance caused by geographical factor

In villages situated far from large towns, it is difficult to get spare parts or technicians.

A communication network should be developed to improve the current situation.

(6) Existence of various pumps

In the Tabora region, various pumps were installed for reasons of the donors. Rare model pumps are difficult to repair, because normal pump technicians are not familiar with rare types or spare parts are difficult to find.

The pump type should be selected taking into account easiness of spare parts procurement. Existing rare models installed into boreholes should be changed to common types to allow use of the borehole for a long period of time.

(7) Structure of well / water quality

If the water of the handpump well is turbid like a Non-protected well, people cannot understand the significance of using a handpump well. Even if it is a deep well, some handpump wells yield turbid water because of fail of construction.

Most of shallow wells with handpump facilities can be opened and it is possible to draw water by bucket without a handpump.

This factor allows users not to be bothered repairing them or paying money.

An educational campaign regarding importance to of using clean water is necessary to improve the current situation. And also the construction quality of wells water is indispensable to supply clean water.

4.5 CONCLUSION

Most of pumps that were repaired in this project were light duty to repair as expected. It indicates that those pumps had been neglected although they could be repaired by light duty repairing works.

If Bearing Bush of AFRIDEV was repaired just after the breakdown, the parts life of the Fulcram pin could be extended. Breakage of concrete pad may cause instability of pump the stand and cause loss of bolts or breakdown of pump. Prompt repairing saves repairing costs and extends pump life as a result.

The training works carried out in this project were profitable for users. There is a case in Moyofuke Village (Igunga District), users tried to repair it by themselves when a pump had trouble. We saw that a meeting to discuss the maintenance of handpump was held by the initiative of trained users in Kasela Village (Nzega District). Training for users and regulatory authority is profitable to establish their ownership awareness to maintain the handpump.

As direct factors to neglect breakdown handpumps are “users cannot procure spare parts or a repairing technician”, “users cannot be bothered repairing by paying money” and “users were not instructed how to maintain them properly”. The lack of responsibility is not only donors but also the regulatory authority.

Neglect of breakdown of the handpump stems from various factors. Discussion among donors, the regulatory authority and users through construction and maintenance will contribute to reduce neglect. But the donor has difficulty doing something after the defect liability period. The user has difficulty doing heavy duty works. The initiative of Direct Water Office is the key to establish maintenance system (parts supply etc.).