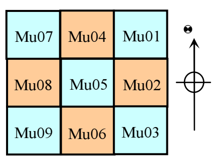
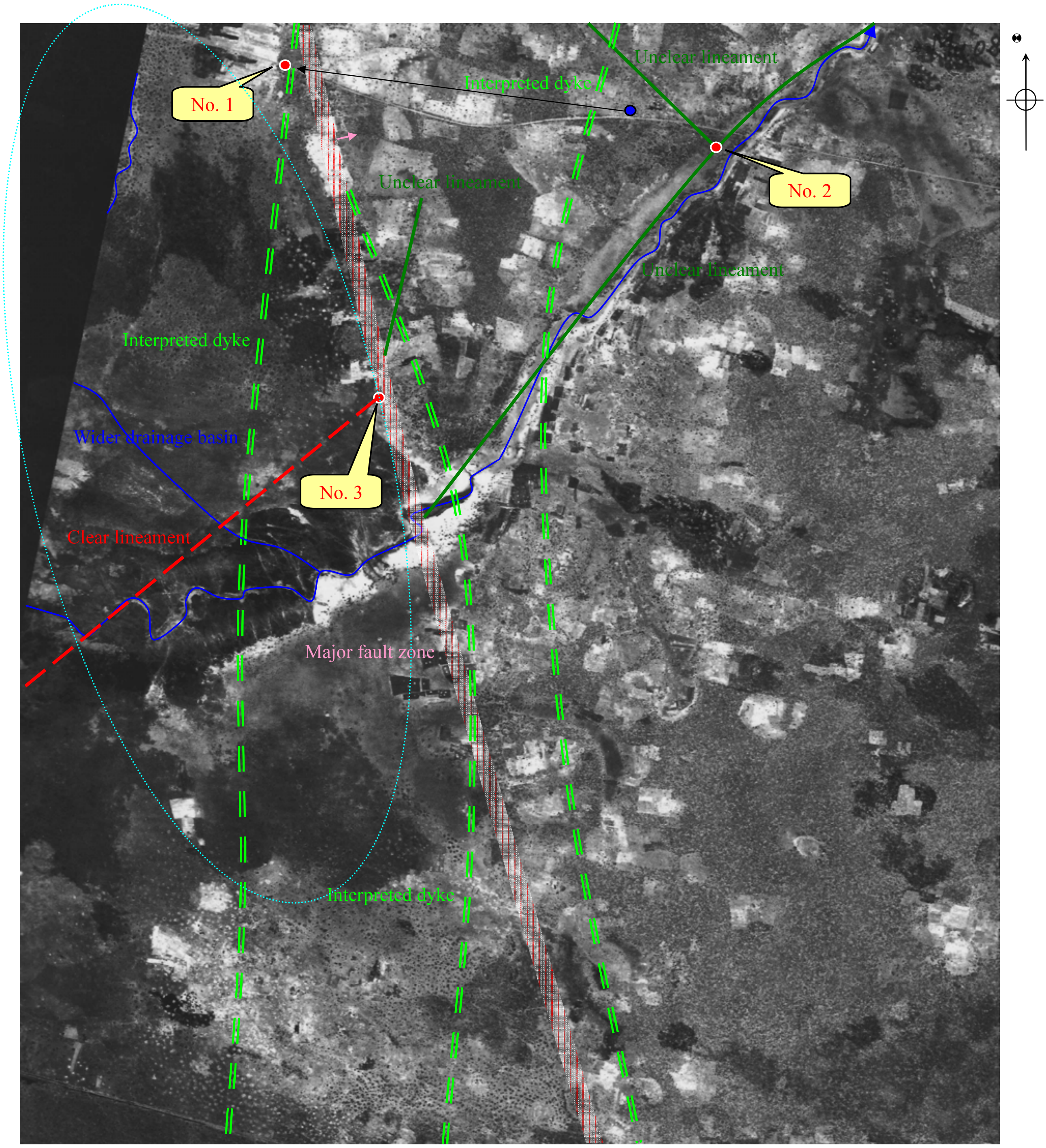
(4) Mpumbuli village

General geology and image interpretation results in Mpumbuli village are shown in Table 1.3.6 and Figure 1.3.7 respectively.

Table 1.3.6 Geologic Feature of Mpumbuli Village

General	Granite (Gb) as a basement in the Tabora region is widely distributed in this village. According to a regional geologic setting, the area is located in the first structural block from the east, which is elongated in N-S direction, tilting slightly eastward. As the western major fault limiting its west end seems to be a reverse fault, it should dip eastward in general. An intersection of fractures makes groundwater storage structure.
Geologic features for further study	- A NNW-SSE trending major fault defined in Phase I study is located 3.5 km west to the village. - NE-SW trending clear and unclear lineaments defined in the study are developed well. - N-S trending interpreted dykes defined in the study are developed very well in the vicinity. - An intersection between major fault and clear lineament forms groundwater storage structure.
Image data used	PRISM stereoscopic view Nadir (N) and Forward (F) Scale: 1:50,000 Index: Mu01 – 09 
Image interpretation	The result of image interpretation is shown in the next page, and the following features were observed, - Topography: Showing extremely flat ground. - Surface: Showing mosaic texture between moderately cultivated lands and forests. - Geology: Granite (Gb) is widely distributed in the area. - Fracture: The NNW-SSE trending major fault and the NE-SW trending clear and unclear lineaments are developed. The N-S trending interpreted dykes are also developed in the vicinity. The intersection between the major fault and clear lineament makes large depression landform. - Drainage: Huge drainage basin sits upstream and its main drainage flows down to northeast. - Others: Poorly accessible by a car except for main road.
Point selection based on image interpretation	- Position: Points No. 1 through No. 3 shown in the next figure are selected as possible positions. - Direction: E-W direction could be recommended for further study. - Hydrogeology: Huge drainage basin upstream as a recharge, clear lineament as a groundwater path and intersection between the major fault and the lineament as a groundwater storage would function.
Remarks	Surface water floods in wet season.



Area name: Usunga (Us)

Portion: Us05N

Data: PRISM image

Scene ID: ALPSMN196233710

Acquisition date: 30/Nov./2009

Look angle: Nadir

Shift: -2

Legend

0 1 2 km

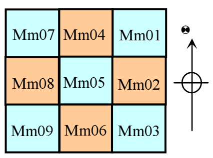
- Point No. with survey direction
- Original point (center of the village)

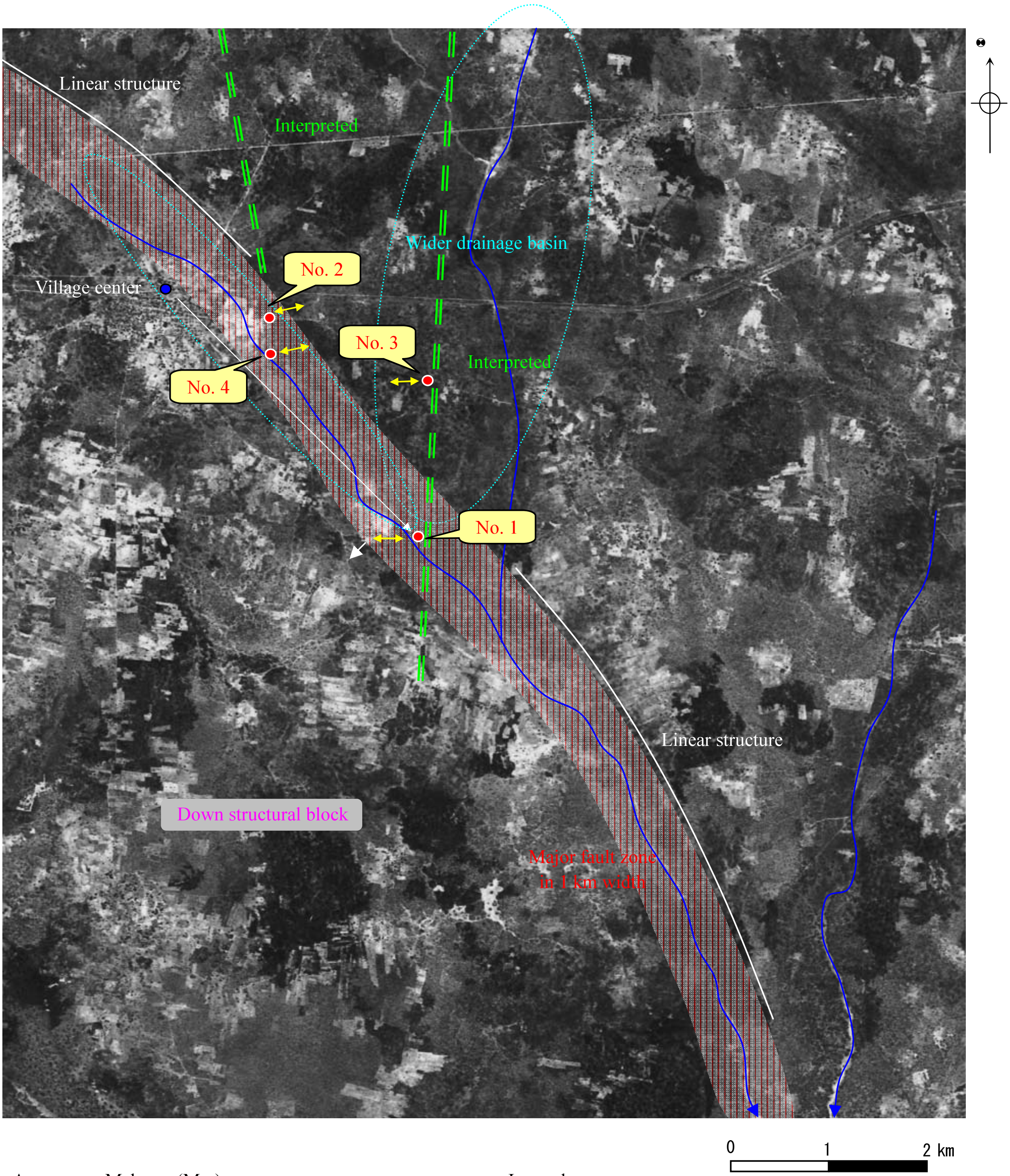
Figure 1.3.7 Image Interpretation Result in Mpumbuli Village

(5) Mabama village

General geology and image interpretation results in Mabama village are shown in Table 1.3.7 and Figure 1.3.8 respectively.

Table 1.3.7 Geologic Feature of Mabama Village

General	Granite (Gb) as a basement in the Tabora region is widely distributed in this village and gneiss (Gn) is also distributed in the northern part of the village. According to a regional geologic setting, the area is located in the most southern part of the forth structural block from the east, which is elongated in N-S direction, tilting slightly eastward. As the south-western major fault limiting its south end seems to be a normal fault, it should dip south-westward in general.
Geologic features for further study	- An intersection between NNE-SSW and NW-SE trending major faults defined in Phase I study is located 2 km north to the village. - Interpreted dykes defined in the study are situated in NNE-SSE direction 2 km north to the village. - A clear lineament defined in the study is situated in NNW-SSE direction 3.5 km northeast to the village.
Image data used	PRISM stereoscopic view Nadir (N) and Forward (F) Scale: 1:50,000 Index: Mm01 – 09 
Image interpretation	The result of image interpretation is shown in the next page, and the following features were observed, - Topography: Showing extremely flat ground except for hilly landform in the northern part. - Surface: Showing mosaic texture between moderately cultivated lands and forests. - Geology: Granite (Gb) is commonly distributed and Gneiss (Gn) crops out in the northern part of the village. - Fracture: The NW-SE trending Major fault is cut by two interpreted dykes in N-S direction. The major fault shows 1 km wide fracture zone indicated by its fault scarves. - Drainage: The basin elongated in N-S direction is wider size than others. Drainage bends toward southeast at a place meeting with the major fault. - Others: almost accessible by a vehicle.
Point selection based on image interpretation	- Position: Points No. 1 through No. 4 shown in the next figure are selected as possible positions. - Direction: E-W and ENE-WSW directions could be recommended respectively for further study. - Hydrogeology: Wider drainage basin upstream as a recharge, fault zone as a groundwater path and intersection between the fault zone and the interpreted dykes as a groundwater storage would function.
Remarks	None



Area name: Mabama (Mm)

Portion: Mm05N

Data: PRISM image

Scene ID: ALPSMN140803705

Acquisition date: 15/Sep./2008

Look angle: Nadir

Shift: -1

Legend

Point No. with survey direction

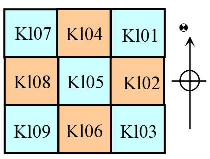
Original point (center of the village)

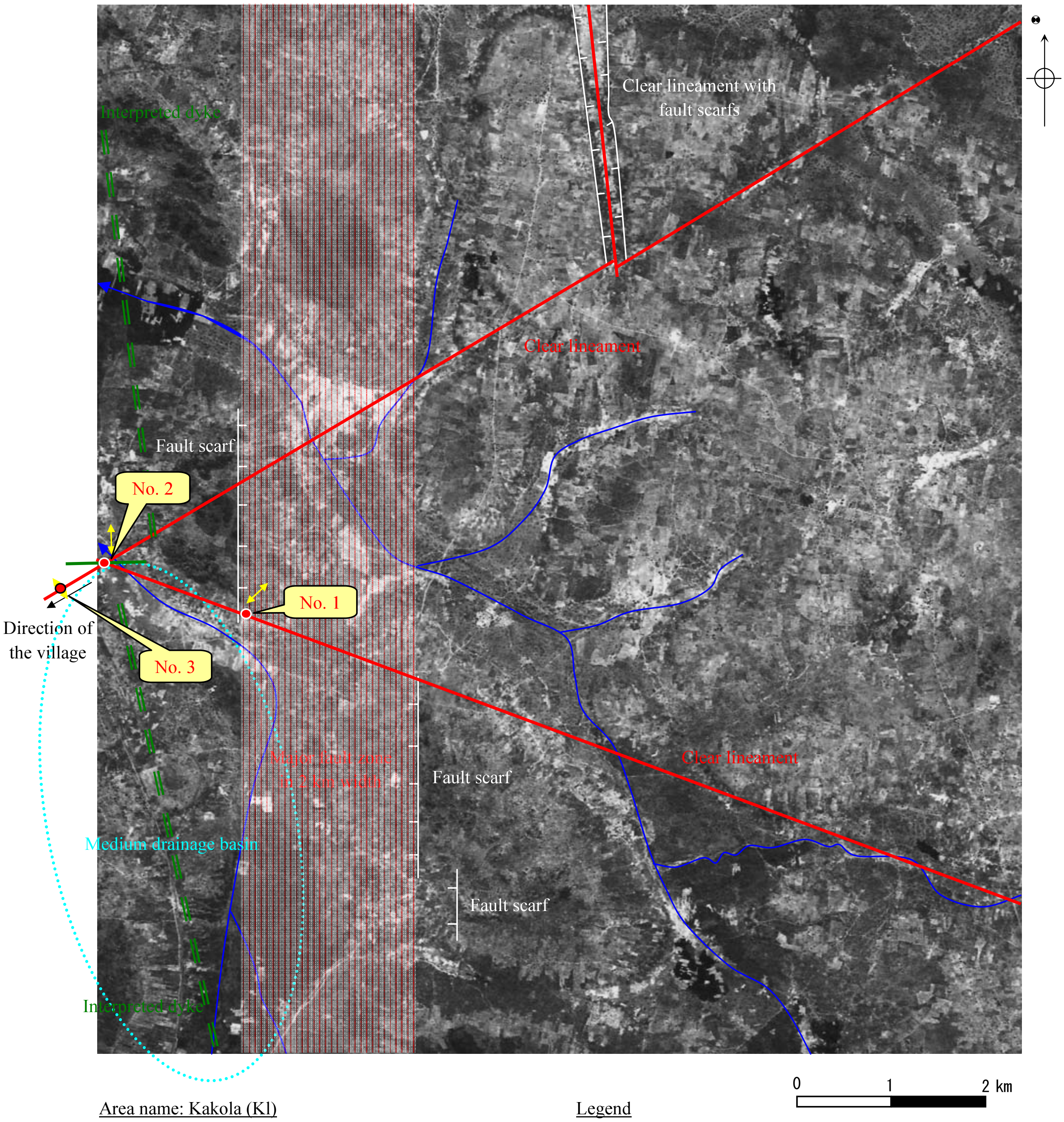
Figure 1.3.8 Image Interpretation Result in Mabama Village

(6) Kakola village

General geology and image interpretation results in Kakola village are shown in Table 1.3.8 and Figure 1.3.9 respectively.

Table 1.3.8 Geologic Feature of Kakola Village

General	Granite (Gb) as a basement in the Tabora region is widely distributed in this village. According to a regional geologic setting, the area is located in the forth structural block from the east, which is elongated in N-S direction, tilting slightly eastward. As the eastern major fault limiting its east end seems to be a reverse fault, it should dip eastward in general.
Geologic features for further study	- A major fault defined in Phase I study is situated in N-S direction 3 km east, interpreted dykes defined in the study are situated in the same direction 2 km east and 1 km east and an unclear lineament defined in the study is also situated in NNW-SSW direction 0.5 km south to the village. - It is important that these lineaments congest into one point.
Image data used	PRISM stereoscopic view Nadir (N) and Forward (F) Scale: 1:50,000 Index: Kl01 – 09 
Image interpretation	The result of image interpretation is shown in the next page, and the following features were observed, - Topography: Showing flat ground except for hilly landform in the northern part. - Surface: Showing high level of land-use as a cultivated land. - Geology: Granite (Gb) is commonly distributed and shows NW-SE trending texture. - Fracture: The major fault is developed in N-S direction and the clear lineaments are developed as well. The major fault shows 2 km wide fracture zone indicated by its fault scarves. - Drainage: The basin elongated in N-S direction is medium size, originating from Tabora Municipality. - Others: Accessible by a vehicle.
Point selection based on image interpretation	- Position: Points No. 1 through No. 3 shown in the next figure are selected as possible positions. - Direction: NE-SW, N-S and NW-SE directions could be recommended for further study. - Hydrogeology: Medium drainage basin upstream as a recharge, fault and lineaments as groundwater paths and fault zone and intersection of lineaments as groundwater storages would function. In addition, alignment of granite might work groundwater path due to weak structure and weathering and the interpreted dykes form groundwater storage due to their low permeability.
Remarks	None



Area name: Kakola (Kl)

Portion: Kl05N

Data: PRISM image

Scene ID: ALPSMN187773695

Acquisition date: 03/Aug./2009

Look angle: Nadir

Shift: +2

Legend

Point No. with survey direction

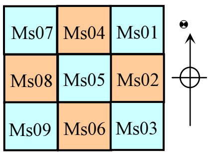
Original point (center of the village)

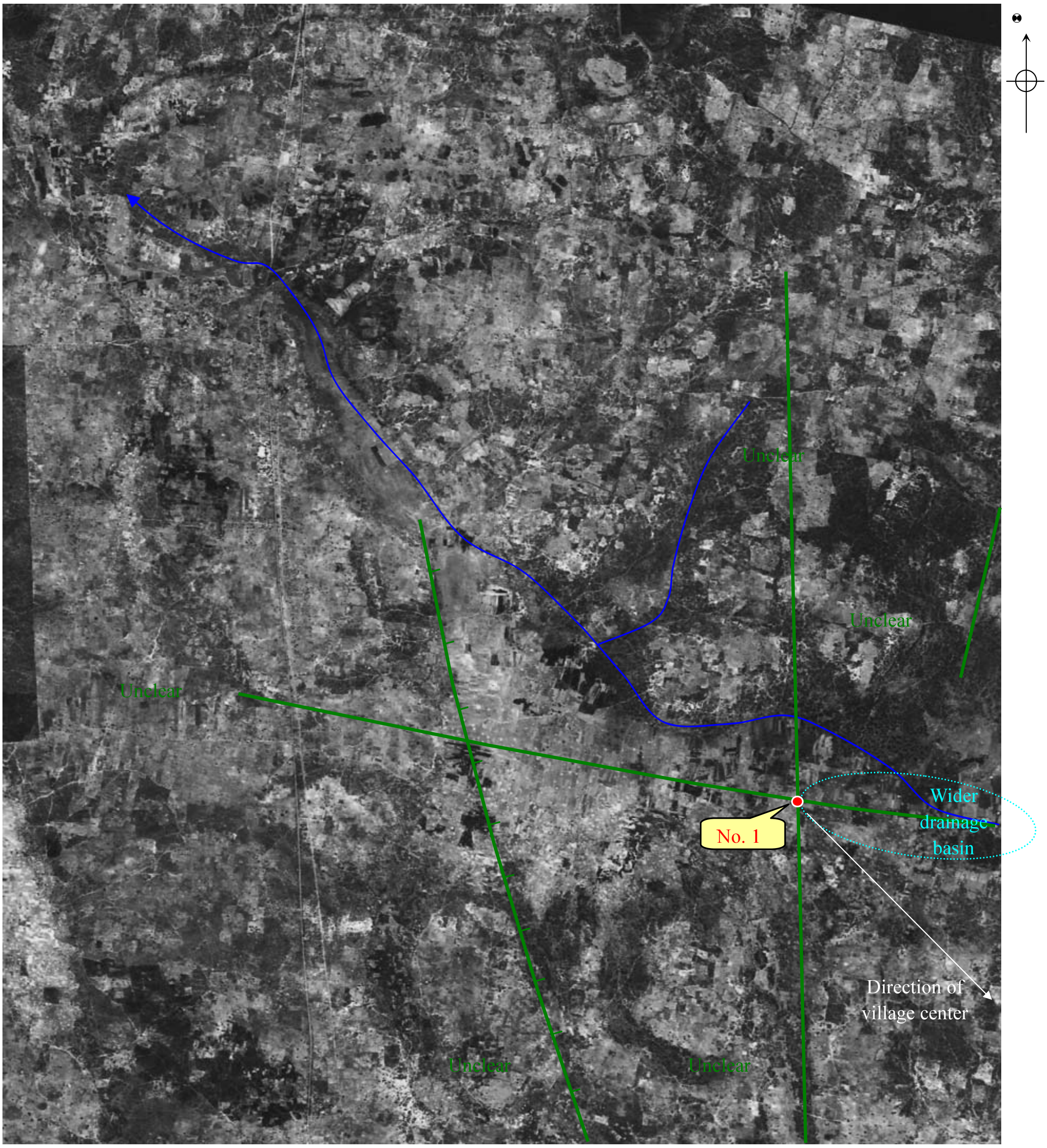
Figure 1.3.9 Image Interpretation Result in Kakola Village

(7) Mabisolo village

General geology and image interpretation results in Mabisilo village are shown in Table 1.3.9 and Figure 1.3.10 respectively.

Table 1.3.9 Geologic Feature of Mabisilo Village

General	Granite (Gb) as a basement in the Tabora region is widely distributed in this village. A regional geologic structure is similar to the one in the Isanga village. According to a regional geologic setting, the area is located in the second structural block from the east, which is elongated in N-S direction, tilting slightly eastward. As the eastern major fault limiting its east end seems to be a reverse fault, it should dip eastward in general.
Geologic features for further study	- An interpreted dyke defined in Phase I study is situated in N-S direction 1 km west to the village and an unclear lineament defined in the study is also situated in the same direction 2 km west to the village. - There is no wider drainage basin in the village than others because of being located near ridge between two drainage basins. - Intersection of two unclear lineaments is located 6 km NW far from the village.
Image data used	PRISM stereoscopic view Nadir (N) and Forward (F) Scale: 1:50,000 Index: Ms01 – 09 
Image interpretation	The result of image interpretation is shown in the next page, and the following features were observed, - Topography: Showing extremely flat ground. - Surface: Showing high level of land-use as a cultivated land. White dots like irrigation ponds are observed on the image. - Geology: Granite (Gb) is commonly distributed in the area. - Fracture: Unclear lineaments are developed in N-S and NNE-SSW directions. The former is almost parallel to the major fault. The intersection of these unclear lineaments sits 6 km northwest to the village. Dips of these lineaments are not observed on the image owing to flat ground expression. - Drainage: Wider basin sits in the north where WNW-ESE trending unclear lineament is located. - Others: Not accessible by a vehicle.
Point selection based on image interpretation	- Position: Point No. 1 shown in the next figure is selected as a possible position. - Direction: NE-SW direction could be recommended for further study. - Hydrogeology: Wider drainage basin upstream as a recharge, unclear lineament as a groundwater path and intersection of unclear lineaments as a groundwater storage would function. Dips of the unclear lineaments should be observed in the field.
Remarks	None



Area name: Mabisilo(Ms)

Portion: Ms04N

Data: PRISM image

Scene ID: ALPSMN091353695

Acquisition date: 12/Oct./2007

Look angle: Nadir

Shift: 0

Legend

- Point No. with survey direction
- Original point (center of the village)

Figure 1.3.10 Image Interpretation Result in Mabisilo Village

1.3.7 FIELD RECONNAISSANCE

The results of field reconnaissance composed of 8 aspects are showed below. Detailed results of the field reconnaissance are also attached in Data Book.

(1) Isanga village

Table 1.3.10 The Result of Field Reconnaissance in Isanga Village

Aspects	Characteristics
Coordination and direction	No. 1: S05°18'35.4", 33°28'41.8" (Way point 041), NE-SW in direction No. 2: S04°02'58.9", 33°12'36.3" (Way point 006) , NE-SW in direction
Distance from the village	No. 1: 2.4 km No. 2: 0.9 km
Recharge	Large drainage basin upstream from south to north in direction
Groundwater Path	Clear lineament
Groundwater storage	Intersection of clear lineament and unclear lineament
Surface condition	Cultivated field
Access	Possible by a car
Remarks	Gold mine nearby Deep well in 58 m depth is also a target in NE – SW direction.

(2) Usunga village

Table 1.3.11 The Result of Field Reconnaissance in Usunga Village

Aspects	Characteristics
Coordination and direction	No. 1:, ENE-WSW in direction No. 2: S05°42'44.7", 32°56'59.8" (Way point 035) , ENE-WSW in direction
Distance from the village	No. 1: 1.4 km No. 2: 1.6 km
Recharge	Large drainage basin upstream from north to south in direction
Groundwater Path	Clear lineament
Groundwater storage	Intersection of clear lineament and unclear lineament
Surface condition	Cultivated field (mainly paddy field)
Access	500 m to a vehicle road
Remarks	Avoiding flood area in wet season

(3) Mpombwe village

Table 1.3.12 The Result of Field Reconnaissance in Mpombwe Village

Aspects	Characteristics
Coordination and direction	No. 1: S05°25'08.4", 32°42'02.7" (Way point 036), NW-SE in direction No. 2: S05°22'28.0", 32°41'11.6" (Way point 037) , NE-SW in direction
Distance from the village	No. 1: 4.4 km No. 2: 1.5 km
Recharge	Large drainage basin upstream from mainly ENE-WSW in direction
Groundwater Path	Unclear lineament
Groundwater storage	Intersection of major fault zone and unclear lineament trapped by fault edge
Surface condition	Cultivated field
Access	Possible by a car
Remarks	Intersection of major fault zone and interpreted dyke is also target.

(4) Mpumbuli village

Table 1.3.13 The Result of Field Reconnaissance in Mpumbuli Village

Aspects	Characteristics
Coordination and direction	No. 1: S05°22'27.9", 32°41'11.5" (Way point 038), E-W in direction No. 2: S05°19'04.2", 33°28'34.6" (Way point 039) , E-W in direction
Distance from the village	No. 1: 3.6 km No. 2: 1.0 km
Recharge	Huge drainage basin upstream
Groundwater Path	Clear lineament
Groundwater storage	Intersection of major fault and clear lineament
Surface condition	Large swamp
Access	Just along the main road
Remarks	Avoiding flood area in wet season. No access road to point No. 3.

(5) Mabama village

Table 1.3.14 The Result of Field Reconnaissance in Mabama Village

Aspects	Characteristics
Coordination and direction	No. 1: S05°08'21.1", 32°32'51.0" (Way point 029), E-W in direction No. 2: S05°07'16.0", 32°31'53.3" (Way point 030) , E-W in direction No. 3: S05°07'42.3", 32°31'50.6" (Way point 032) , E-W in direction No. 4: S05°07'38.7", 32°32'49.2" (Way point 031) , E-W in direction
Distance from the village	No. 1: 3.3 km No. 2: 1.2 km No. 3: 1.4 km No. 4: 3.2 km
Recharge	Large and small drainage basins upstream from mainly north to south in direction
Groundwater Path	Major fault zone and interpreted dyke
Groundwater storage	Intersection of major fault zone and interpreted dyke trapped by its dyke
Surface condition	Primary forest
Access	Possible by a car
Remarks	Intersection of major fault zone and another interpreted dyke is target as well.

(6) Kakola village

Table 1.3.15 The Result of Field Reconnaissance in Kakola Village

Aspects	Characteristics
Coordination and direction	No. 1: S04°51'58.8", 32°49'25.3" (Way point 025), NE-SW in direction No. 2: S04°51'39.7", 32°50'09.3" (Way point 020) , N-S in direction No. 3: S04°51'49.1", 32°49'50.9" (Way point 021) , NW-SE in direction
Distance from the village	No. 1: 2.6 km No. 2: 1.4 km No. 3: 0.5 km
Recharge	Medium drainage basin upstream from south to north in direction
Groundwater Path	Congestion among clear lineaments, unclear lineament and interpreted dyke in the vicinity of major fault zone
Groundwater storage	Intersection of clear lineaments trapped by interpreted dyke
Surface condition	Cultivated field (mainly paddy field)
Access	Possible by a car
Remarks	Railroad built nearby

(7) Mabisilo village

No investigation in the field.

1.3.8 HYDRO-GEOLOGICAL INTERPRETATION

The result of hydro-geological interpretation for each Level-2 village is shown in Table 1.3.16. Their contents are as follows,

Table 1.3.16 Comparison among Hydro-geological Interpretation for Each Level-2 Village

Village name	Point	Recharge	Groundwater path	Storage	Sealing	Water quality
Isanga	No. 1	A	A	B	A	B
	No. 2	B	B	C	B	B
Usunga	No. 1	A	A	B	A	A
	No. 2	A	A	B	A	A
Mpombwe	No. 1	A	A	A	A	A
	No. 2	B	A	A	A	A
Mpumbuli	No. 1	A	A	A	A	A
	No. 2	A	A	B	A	A
	No. 3	A	A	A	A	A
Mabama	No. 1	A	A	A	A	A
	No. 2	B	A	A	A	A
	No. 3	A	B	A	A	A
	No. 4	B	A	A	A	A
Kakola	No. 1	A	A	A	A	A
	No. 2	A	B	A	A	A
	No. 3	B	A	B	A	A
Mabisilo	No. 1	A	A	B	A	A

Note: A/ excellent, B/ fair, C/ poor, N/ no information

Regarding a recharge, expression 'A' in the table shows possessing relatively larger drainage basin upstream than others. For instance, expression 'B' is common in point No. 2 because of possessing another smaller drainage basin than No.1.

Regarding groundwater path, it makes expression 'A' that fractures such as major faults, clear lineaments and unclear lineaments exist along the drainage. For instance, expression 'B' is common in point No. 2 because of poor development of fractures along the drainage.

Regarding groundwater storage, expression 'A' shows storage structure formed by major faults and dykes, expression 'B' done by intersection of lineaments and expression 'C' done by single lineament. For instance, point No. 2 of Isanga village marks expression 'C', while deep groundwater well exists in the vicinity.

Most of the points mark expression 'A' as a seal because of locating in drainages. Isanga village marks expression 'B' as a water quality because of poor quality record from Phase I study. There is no precise information about groundwater level.

Generally, point No.1 in each village marks excellent conditions in the view of hydrogeology.

1.3.9 RESULT OF ANALYSIS FOR TARGET VILLAGES CONCLUSION

The objective of this survey is to extract hydro-geologically potential points for the geophysical exploration in the target villages for the priority project by the use for the collection and the analysis of existing data, high ground resolution satellite PRISM image interpretation and field reconnaissance.

It is important that we make a requirement for groundwater potential into consideration when interpreting the images. There exist 6 requirements in the study, particularly first three items, namely recharge, groundwater path and groundwater storage are indispensable.

As a conclusion, following points were selected through this study,

Isanga village, Nzega District: 2 points are selected and NE-SW direction is recommended in further study. An attention should be paid at the location of a gold mine and water quality.

Usunga village, Sikonge District: 2 points are selected and ENE-WSW direction is recommended in further study. All requirements are satisfied at the point, but drainage basins upstream are smaller than others.

Mpombwe village, Sikonge District: 2 points are selected and NW-SE and NE-SW directions are recommended in further study. All requirements are satisfied at Point No. 1 because of fault zone developed very well.

Mpumbuli village, Tabora Rural District: 3 points are selected and E-W direction is recommended in further study. All requirements are completely satisfied at Point No. 1. Point No. 3 shows poor accessibility instead of all requirements.

Mabama village, Tabora Rural District: 4 points are selected and E-W direction is recommended in further study. All requirements are satisfied at Point No. 1 because of fault zone developed very well.

Kakola village, Tabora Municipality: 3 points are selected and NE-SW, N-S and NE-SW directions are recommended respectively in further study. All requirements are satisfied at Point No. 1 because of fractures developed very well.

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CHAPTER 2 GEOPHYSICAL EXPLORATION

2.1 ABSTRACT

The geophysical exploration was carried out to select the candidate points for the test well drilling survey and the candidate points of the water sources for the priority project.

2.2 OBJECTIVES

1) To delineate promising areas for drilling at villages envisioned as level-1 schemes

2) To choose promising areas for drilling at villages envisioned as Level-2 schemes

3) To choose promising areas for drilling at water quality check sites in Igunga district

2.3 SURVEY CONTENTS

2.3.1 GEOPHYSICAL EXPLORATION METHODS

The EM method, radon method and 2D Electrical sounding were adopted in the Study.

Table 2.3.1 Features of Geophysical Exploration Methods

Methods	Handiness	Volume of information		Remarks
EM Method	○	△	Apparent Electrical Conductivity of the Horizontal Direction(1D)	It is possible quickly, but there is little information.
Radon Method	○	△	Fracture Zone on Surface(1D)	Same as the above. The accuracy of survey improves when this method is used together with the 2D Electrical Sounding
2D Electrical Sounding	×	○	Resistivity of Underground Section (2D)	This method gets much information, but needs a lot of survey time.

○:good △:fair ×: poor

Three kinds of geophysical exploration shown above were carried out according to the following figure.

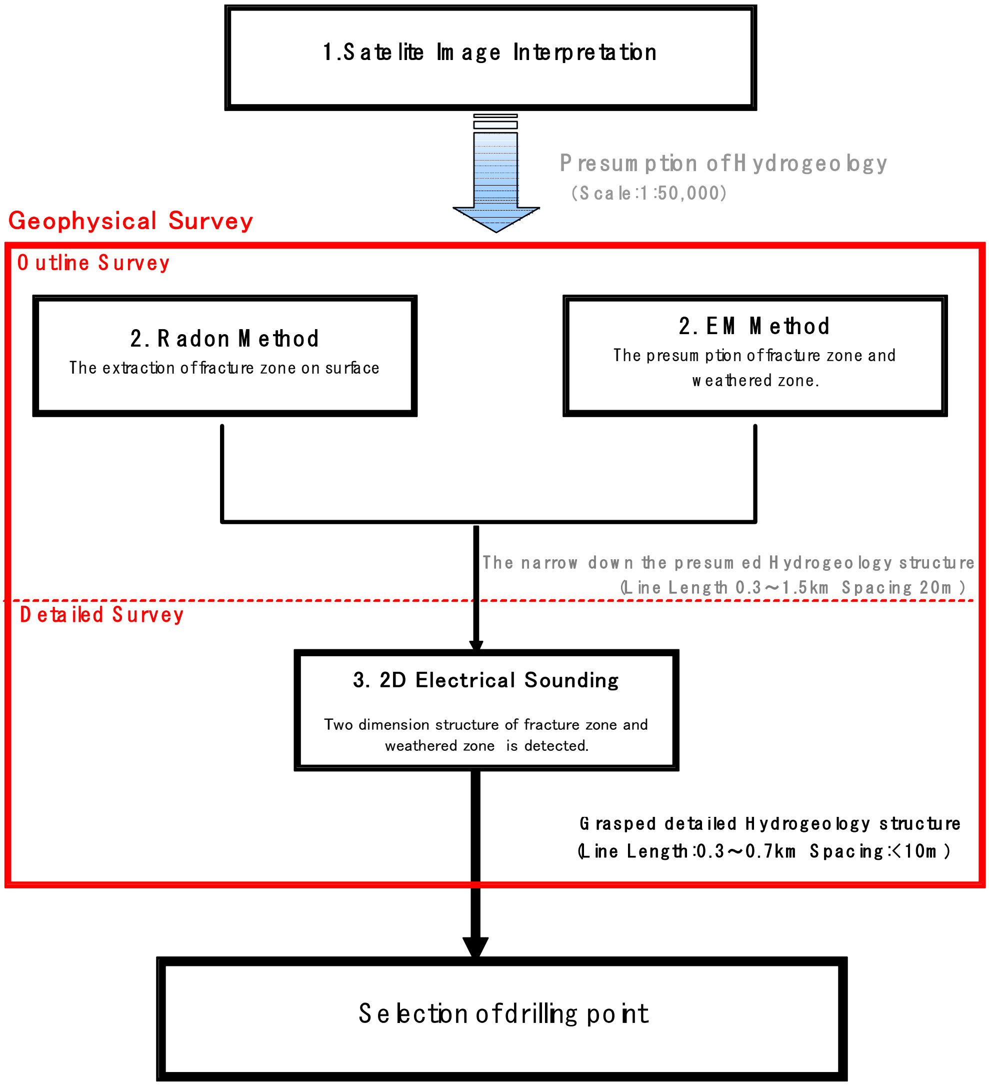


Figure 2.3.1 Flow of Geophysical Survey in the Study

2.3.2 AMOUNTS OF GEOPHYSICAL EXPLORATION.

(1) Target Villages for Level-1 Scheme

EM method was carried out at 36 sub-villages in 14 villages in Tabora Region. Numbers of the survey lines was 98 and the total line length was 44.38km. The area name and amounts of exploration are listed in the following Table 2.3.2.

Table 2.3.2 Amounts of Geophysical Exploration at the Villages for Level-1 Scheme

District / Municipality	Village	Sub-Village	Line No.	Line Length
Igunga District	Busomeke	Kagua Kati	2	1.2km
		Kusini-A	2	1.1km
		Bulyawela	2	1.1km
	Kalemela	Kusini Mashariki	2	1.1km
		Kusini	2	1.0km
		Mashariki	2	1.0km
Nzega District	Kitangili	Bukoli	3	0.8km
		Shandu	5	1.0km
	Makomelo	Idubula	2	1.0km
		Kalangale	2	1.0km
		Makomelo	2	0.9km
	Wela	Kityelo	2	1.0km
		Mashariki	2	1.2km
		Usalama	2	0.8km
Sikonge District	Kasandalala	Kasandalala	2	1.2km
		Ujungu	2	1.2km
		Utawambogo	2	1.3km
Tabora Rural District	Ufuluma	Imalamapaka	2	1.1km
		Iyogelo	2	1.0km
		Ufuluma Senta	2	1.1km
Tabora Municipality	Misha	Misha Kati	4	1.6km
		Utusini	4	2.3km
	Uyui	Mandelo	4	1.14km
		Milambela	4	1.4km
		Mtukula	4	1.4km
Urambo District	Imalamakoye	Imalamakoye-B	5	1.7km
		Imalamakoye-D	3	1.0km
	Kalembela	Kawawa	4	1.7km
		Mwinye	4	1.5km
	Kapilula	Kilambero	2	1.54km
		Mlimani	3	1.6km
	Kiloleni	Kiloleni-A	4	1.9km
		Kiloleni-B	3	1.4km
	Nsungwa	Nsungwa No.7	2	1.1km
		Nyota	2	0.8km
		Usonga	2	1.2km
Total	14	36	98	44.38km

(2) Target Villages for Level-2 Scheme and Water Quality Check Site

A geophysical survey was carried out in 7 villages of the target Level-2 scheme. The EM method and Radon Method were done as an outline survey. Afterwards, 2D Electrical sounding was done as a detailed survey. About 3 water quality check sites, these do not require much information. Therefore, only a 2D electrical sounding was carried out

Table 2.3.3 shows the amounts of geophysical exploration.

Table2.3.3 Amounts of Geophysical Exploration at the Villages for Level-2 Scheme and Water Quality Check Site

object	District/ Municipality	Village	EM Method		Radon Method		2D Electrical Sounding	
			Line No.	Line Lengh (km)	Line No.	Line Lengh (km)	Line No.	Line Lengh (km)
Level-2 scheme	Nzega Dist.	Isanga	2	0.96	2	1	6	2.96
	Sikonge Dist.	Usunga	2	1.3	2	1.3	6	3.29
		Mpombwe	4	2	4	2	8	3.3
	Tabora Rural Dist.	Mpumbuli	1	0.6	1	0.6	2	0.95
		Mabama	4	2.9	4	2.64	6	3.18
		Ufuluma	-	-	-	-	1	0.75
	Tabora Mun.	Kakola	5	1.84	5	1.84	7	2.67
	Sub-total		**18**	**9.6**	**18**	**9.38**	**36**	**17.1**
Water quality check	Igunga Dist.	Igumo	-	-	-	-	1	0.64
		Buhekela	-	-	-	-	2	0.95
		Kagongwa	2	0.8	-	-	2	1.06
	Sub-total		**2**	**0.8**	**-**	**-**	**5**	**2.65**
Total			**20**	**10.4**	**18**	**9.38**	**41**	**19.75**

2.3.3 Basic Principles and Methodology

(1) EM Method

EM method was carried out using EM34-3 manufactured by Geonics. EM34-3 consists of a transmitter with coil and a receiver with coil. The distance between coils of the transmitter and the receiver is 40m. Electromagnetic wave of 0.4Hz is transmitted by the transmitter and the secondary field is measured by the receiver to calculate the apparent conductivity. The exploration depth is about 60m. The measurement was carried out every 20m along the survey line.

The study area is dominated by bedrock and it is considered that fault or fracture zone and thick weathered zone has potentiality of groundwater. The apparent conductivity changes rapidly at the fault or fracture zone and is relatively high where the weathered zone is thick.

(2) Radon Method

Radon is a radioactive, colorless, odorless, tasteless noble gas, occurring naturally as the decay product of radium. There are three isotopes of radon as follows;

- 222Rn (Rn) called radon belongs to uranium series has a half-life of 3.8235 days.
- 220Rn (Tn) called thoron belongs to thorium series has a half-life of 55.6 seconds.
- 219Rn (An) called actinon belongs to actinium series has a half-life of 3.96 seconds.

It is empirically known that radon concentration is generally higher at the ground surface where fault or fracture exists. The reason of it is considered as follows;

- Uranium or thorium which is parent nuclide of radon is dissolved into groundwater and comes up through the fracture toward the surface. As the results, it is deposited at the surface soil layer and forms the source of radon.
- Radon comes up through the fracture accompanied by groundwater or carrier gas such as H2, CO2 or H2O and is concentrated within the surface soil layer.

Radon is unique natural radioactive element which makes alpha decay and exists in the form of gas. Therefore radon concentration can be quantified by measuring the amount of alpha particles in the soil gas.

The amount of alpha particles in the soil gas is measured by scintillation method. A scintillator such as Zinc sulfide excited by alpha particles emits light (it is called scintillation). The scintillation counter detects this light using photomultiplier tube.

Radon method is carried out using Radon detector RD-200 manufactured by EDA. RD-200 consists of scintillation counter, soil gas cell and soil gas probe.

The procedure of measurement is as follows;

1) Making hole.

Make the sample hole using soil auger. Leave the auger in the hole until the soil gas probe will be installed.

2) Measurement of background value.

Squeeze the rubber bulb pump 5 or 6 times keeping the soil gas probe in the air.

Set the period select switch on the detector "1 min".

Carry out a measuring of background value 1 minute by pressing the "SAMPLE" button on the detector..

If the background value is higher than 10 cpm, ventilate the cell and remeasure.

If the background value is still high, change the cell.

3) Pumping the soil gas into the cell and measurement.

Carefully remove the auger from the hole and insert the soil gas probe into the hole making as good as seal as possible.

Set the period select switch on the detector "Manual".

Squeeze the pump 5 or 6 times.

Immediately after pumping, start measurement by pressing the "SAMPLE" button on the detector.

Read the value on the LED display at 1, 2 and 3 minutes after pressing the "SAMPLE" button.

4) Ventilation of the cell

Immediately flush out the cell by removing the soil probe from the ground and pumping air through the system.

The concentrations of radon and thoron are calculated as follows using measured values of B.G.(background value), V1(value at 1 minute), V2(value at 2 minutes) and V3(value at 3 minutes).

$Rn = 0.868*C3 + 0.317*C2 - 0.339*C1$,

$Tn = 0.862+C1 - 0.674*C3$

where

Rn, Tn are concentrations of radon and thoron respectively.

$C1 = V1 - B.G.$

$C2 = V2 - V1 - B.G.$

$C3 = V3 - V2 - B.G.$

The half life time of Tn is shorter than that of Rn and Tn is decayed while radon gas move upward through fracture. Therefore, Rn concentration and the ratio of Rn/Tn both are high at fracture zone.

(3) 2D Electrical Sounding

The Measurement of resistivity uses a pair of current electrodes and another pair of potential electrodes that are installed in the surface of the earth. Current a direct current or long exchange of a cycle is sent from a current-electrode, and measures the potential difference which is produced with a potential-electrode. According to the purpose and efficiency of the investigation, there are several methods in how (electrode arrangement) in the surface of the earth of a current-electrode and a potential-electrode can be arranged.

Table 2.3.4 Feature of Array Settings

Array Settings	Efficiency	Effective depth	Sensitivity	Density of data
Pole-Pole	◎	◎	×	◎
<u>**Pole-Dipole**</u>	<u>○</u>	<u>○</u>	<u>○</u>	<u>◎</u>
Dipole-Dipole	△	×	◎	◎
Eltrun	×	△	△	○
Wenner	×	○	×	○
Schlumberger	△	○	○	−

◎:Excellent ○:good △:fair ×: difficulty −:poor

A high-density explorations (Pole-Pole, Pole-Dipole, Dipole-Dipole array) are suitable for the extraction of the fracture zone.

The Pole-Pole array has the widest horizontal coverage. However, it does not have the highest resolution.

The Dipole-Dipole array has high sensitivity but the signal strength is small. Therefore, it is not suitable for a deep survey (Less than 50m).

The Pole-Dipole array is the most suitable method for this area among these (Target: fissure water at GL-50-100m). Because this array is positioned in the middle of the "Pole-Pole array" and the "Dipole-Dipole array", namely the "Pole-Dipole array" has reasonably good signal strength and sensitivity. Figure 2.3.2 shows the Pole-Dipole configuration.

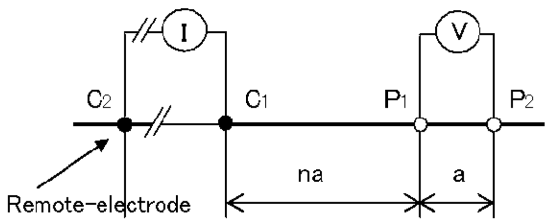


Figure 2.3.2 Pole-Dipole Configuration

The apparent resistivity is expressed as,

$$\rho a=2n(n+1)\pi aV/I$$

ρa: apparent resistivity (Ω-m) n: separation coefficient a: spacing V: Potential I: Current

The main measurement apparatuses are shown in the following;

Table 2.3.5 Measuring Instruments

Name	Type	Specification	Quantity
Measurement equipment	McOHM profiler 4	Maximum voltage:400V Maximum current: 1000mA ((in case of the power booster using)	1 set
Booster	POWER BOOSTER MODEL-2142	Conduction current: 250,500,750,1000mA	1 set
Observation Cable	Exclusive cable	10m interval and 16 ingredient	2 set
electorode	steel-manufacture stick	φ15mm l=50cm	80 set
The electric wire for remote electrode	Single line	Electric strength: 600V	1000m
Battery	vehicle battery	12V 50AH	2 set

2.4 RESULTS OF GEOPHYSICAL EXPLORATION OF LEVEL-1

2.4.1 IGUNGA DISTRICT

EM method was carried out at 6 sub-villages in 2 villages in Igunga district.

(1) Busomeke Village

1) Kagua Kati sub-village

Exploration was carried out along 2 lines.

The change of the apparent conductivity suggesting fault or fracture is not recognized. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

2) Kusini-A sub-village

Exploration was carried out along 2 lines.

The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 180m and 260m along the line E-01.

3) Bulyawele sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is not recognized.

It is estimated that the thickness of weathered zone is relatively thick at the northern part and the western part of the survey area. But it is considered that the thickness of weathered zone is not thick because the apparent conductivity shows low value in whole.

(2) Kalemela Village

1) Kusini Mashariki sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 580m and 640m along the line E-01 and between 240m and 280m along the line E-02.

2) Kalemela village, Kusini sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 280m and 320m along the line E-02.

3) Kalemela village, Mashariki sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 100m - 180m and 220m - 340m along the line E-01 and between 180m and 220m along the line E-02.

2.4.2 NZEGA DISTRICT

EM method was carried out at 8 sub-villages in 3 villages in Nzega district.

(1) Kitangili Village

1) Bukoli sub-village

Exploration was carried out along 3 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is not recognized. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

2) Shandu sub-village

Exploration was carried out along 5 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 40m and 60m along the line E-03 and between 120m and 180m along the line E-04. Relatively high apparent conductivity zone is distributed from 40m of the line E-03 to 100m of the line E-04 and 40m of the line E-05 in the direction of NW-SE.

(2) Makomelo Village

1) Idubula sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 80m - 120m and 400m - 600m along the line E-02.

2) Kalangale sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is not recognized. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

3) Makomelo sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is not recognized. The apparent conductivity is higher at the western part of the line E-01, and it is considered that the thickness of weathered zone is relatively thick.

(3) Wella village,

1) Kityelo sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 80m - 140m and 380m - 440m along the line E-01. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

2) Wella village, Mashariki sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 540m and 600m along the line E-02.

3) Wella village, Usalama sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is not recognized. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

2.4.3 SIKONGE DISTRICT

EM method was carried out at 3 sub-villages in 1 villages in Sikonge district.

(1) Kasandalala Village

1) Kasandalala sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 460m and 520m along the line E-02. The apparent conductivity is relatively high at the southern part.

2) Ujungu sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 580m and 800m along the line E-01. The apparent conductivity is relatively high at the eastern part.

3) Utawambogo sub-village

Exploration was carried out along 2 lines.

The apparent conductivity shows high value in whole. Therefore, it is considered that the thickness of weathered zone is thick. The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 420m and 480m along the line E-01 and between 100m and 200m along the line E-02.

2.4.4 TABORA RURAL DISTRICT

EM method was carried out at 3 sub-villages in 1 village in Tabora Rural district.

(1) Ufuluma Village

1) Imalamapaka sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 140m - 200m and 380m - 440m along the line E-02.

2) Iyogelo sub-village

Exploration was carried out along 2 lines.

The apparent conductivity shows high value in whole. Therefore, it is considered that the thickness of weathered zone is thick. The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 360m and 380m along the line E-02. The apparent conductivity is relatively high at the eastern part.

3) Ufuluma sub-village

Exploration was carried out along 2 lines.

The apparent conductivity becomes higher at the eastern part and it is considered that the thickness of weathered zone is thicker at the eastern part.

2.4.5 TABORA MUNICIPALITY

EM method was carried out at 5 sub-villages in 2 villages in Tabora Municipality.

(1) Misha Village

1) Misha Kati sub-village

Exploration was carried out along 4 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 120m and 200m along the line E-04. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

2) Utusini sub-village northern part

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 400m and 600m along the line E-04.

3) Utusini sub-village southern part

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is not recognized. It is estimated that the thickness of weathered zone is thick at the southern part of the line E-03 and at the western part of the line E-04 because the apparent conductivity shows relatively high value.

(2) Uyui Village

1) Mandelo sub-village

Exploration was carried out along 4 lines.

The apparent conductivity shows relatively high value between 0m and 80m along the line E-01 and between 300m and 380m along the line E-02. This anomaly zone is distributed in the direction of north-south on the plan map.

The anomaly of the apparent conductivity suggesting fault or fracture is not recognized. It is estimated that the thickness of weathered zone is thick at the southern part of the line E-03 and at the western part of the line E-04 because the apparent conductivity shows relatively high value.

2) Milambela sub-village

Exploration was carried out along 4 lines.

It is estimated that the thickness of weathered zone is thick at eastern part of the survey area because the apparent conductivity shows relatively high value. The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 220m and 400m along the line E-04.

3) Mtukula sub-village

Exploration was carried out along 4 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 200m and 220m along the line E-01. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

2.4.6 URAMBO DISTRICT

EM method was carried out at 11 sub-villages in 5 villages in Urambo district.

(1) Imalamakoye Village

1) Imalamakoye B sub-village

Exploration was carried out along 5 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is not recognized. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

2) Imalamakoye D sub-village

Exploration was carried out along 3 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 140m and 180m. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

(2) Kalembela Village

1) Kawawa sub-village

Exploration was carried out along 3 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is not recognized. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

2) Mwinye sub-village

Exploration was carried out along 4 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 180m and 240m along the line E-01 and between 240m and 300m along the line E-04. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

(3) Kapilula Village

1) Kilambero sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 1120m and 1200m along the line E-01 and between 60m and 120m along the line E-02. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

2) Mlimani sub-village

Exploration was carried out along 3 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is not recognized. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

(4) Kiloleni Village

1) Kiloleni A sub-village

Exploration was carried out along 4 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 320m and 500m along the line E-01 and between 0m and 100m along the line E-02. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

2) Kiloleni village, Kiloleni B sub-village

Exploration was carried out along 4 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 240m and 300m along the line E-03 and between 220m and 280m along the line E-04. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

(5) Nsungwa Village

1) Nsungwa No.7 sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 420m and 480m along the line E-02. The apparent conductivity shows low value in whole. Therefore, it is considered that the thickness of weathered zone is thin.

2) Nyota sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 40m and 60m along the line E-02. It is estimated that the thickness of weathered zone is high at the eastern part of the line E-01 (0m - 280m) because the apparent conductivity shows relatively high value.

3) Usonga sub-village

Exploration was carried out along 2 lines.

The anomaly of the apparent conductivity suggesting fault or fracture is recognized between 340m and 400m along the line E-01.

2.4.7 CONCLUSION

The study area is dominated by bedrock and it is considered that fault or fracture zone and thick weathered zone has potentiality of groundwater. As a result of EM survey, faults or fractures are estimated at 26 sub-villages and thick weathered zone are at 6 sub-villages. Table 2.4.1 shows the results of geophysical survey for Level-1.

The results show that faults or fractures are detected at many points but thick weathered zone is rare. Especially, in Igunga and Nzega district located in northern part of Tabora region, thick weathered zone is not recognized at all. In the survey area in Igunga and Nzega district, the outcrop of bedrock is recognized everywhere. Therefore, the thickness of weathered zone is generally thin in there districts.

The detailed structure of estimated fault of fracture and weathered zone is not cleared because that EM method is just horizontal survey. Therefore, the detailed survey such a 2D resistivity method should be done before drilling is conducted.

Table 2.4.1 Results of Geophysical Exploration at the Villages for Level-1 Scheme

District / Municipality	Village	Sub-Village	Type of promising area	
			Fault or fracture	Thick weathered zone
Igunga	Busomeke	Kagua Kati		
		Kusini-A	O	
		Bulyawela		
	Kalemela	Kusini Mashariki	O	
		Kusini	O	
		Mashariki	O	
Nzega	Kitangili	Bukoli		
		Shandu	O	
	Makomelo	Idubula	O	
		Kalangale		
		Makomelo		
	Wela	Kityelo	O	
		Mashariki	O	
		Usalama		
Sikonge	Kasandalala	Kasandalala	O	
		Ujungu	O	
		Utawambogo	O	O
Tabora Rural	Ufuluma	Imalamapaka	O	
		Iyogelo	O	O
		Ufuluma Senta		O
Tabora Municipality	Misha	Misha Kati	O	
		Utusini	O	O
	Uyui	Mandelo	O	
		Milambela	O	O
		Mtukula	O	
Urambo	Imalamakoye	Imalamakoye-B		
		Imalamakoye-D	O	
	Kalembela	Kawawa		
		Mwinye	O	
	Kapilula	Kilambero	O	
		Mlimani		
	Kiloleni	Kiloleni-A	O	
		Kiloleni-B	O	
	Nsungwa	Nsungwa No.7	O	
		Nyota	O	O
		Usonga	O	
Total	14	36	26	6

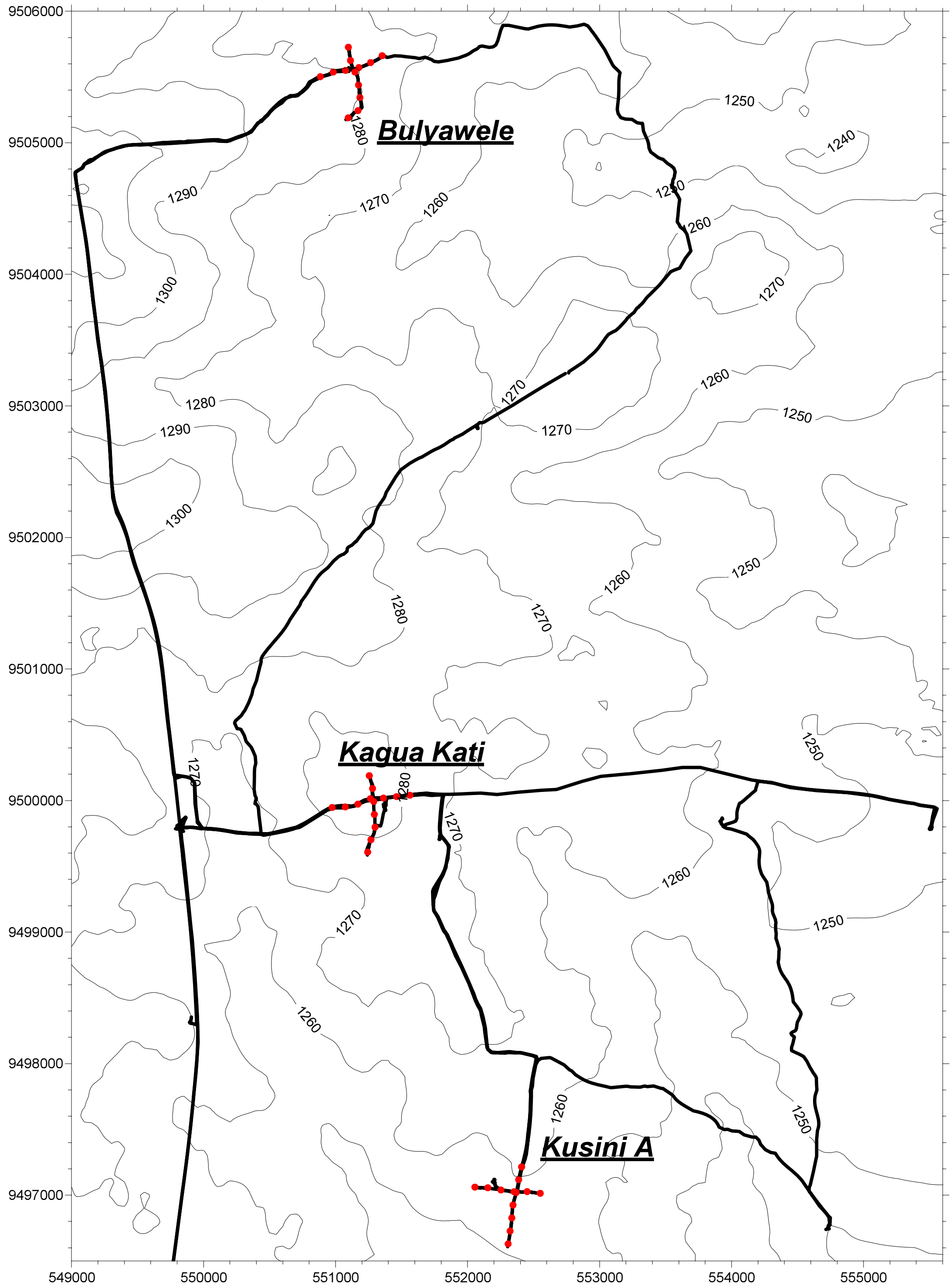


Figure.2.4.1 Geophysical survey location at Busomeke village in Igunga district

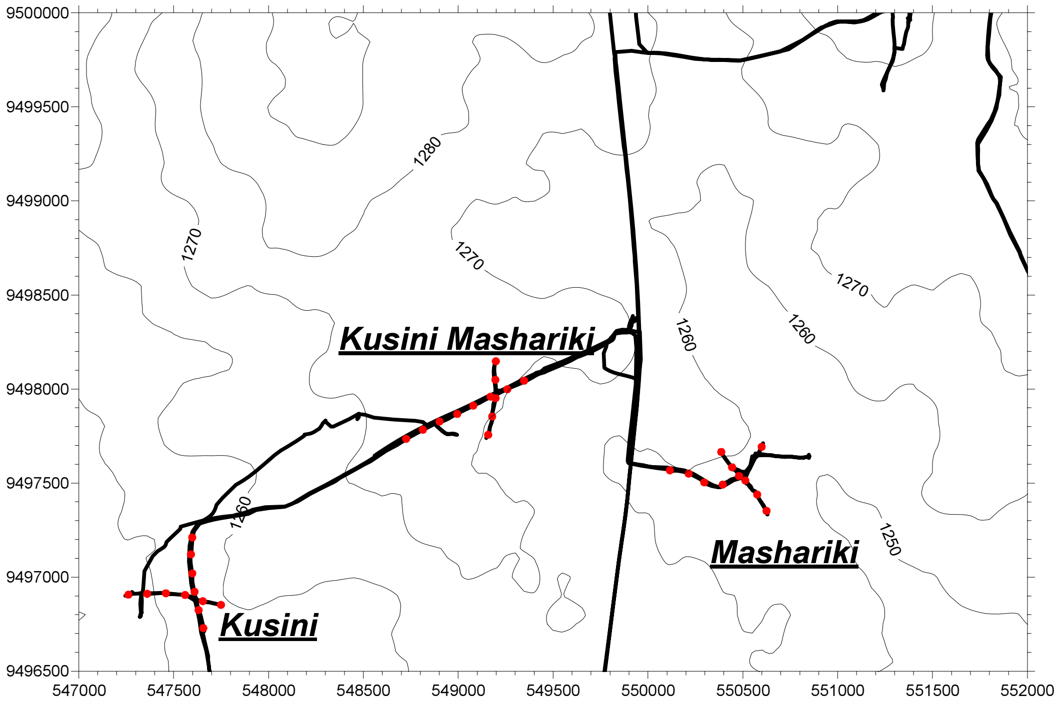


Figure.2.4.2 Geophysical survey location at Kalemela village in Igunga district

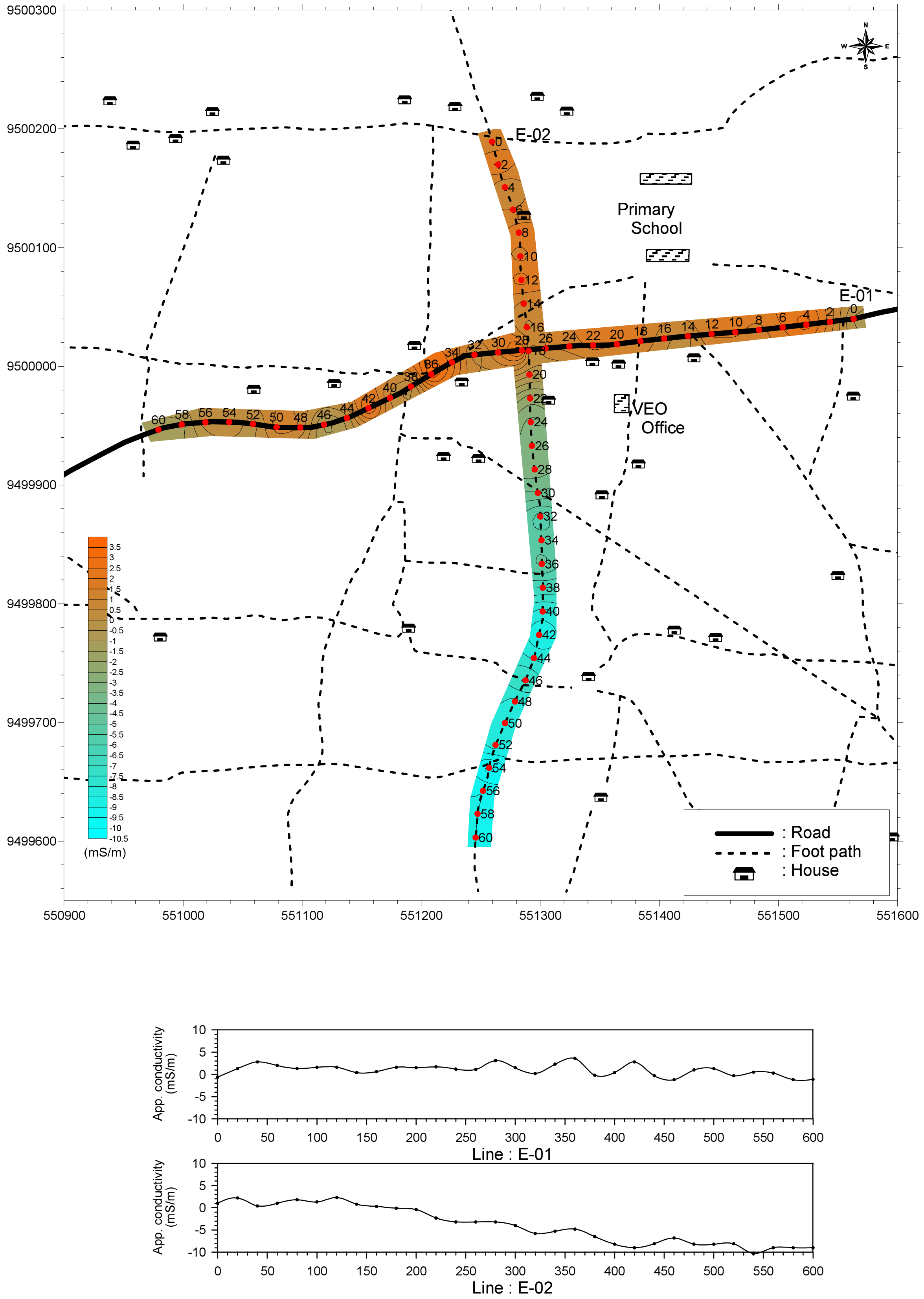


Figure.2.4.3 Geophysical survey results at Kagua Kati sub-village in Busomeke village

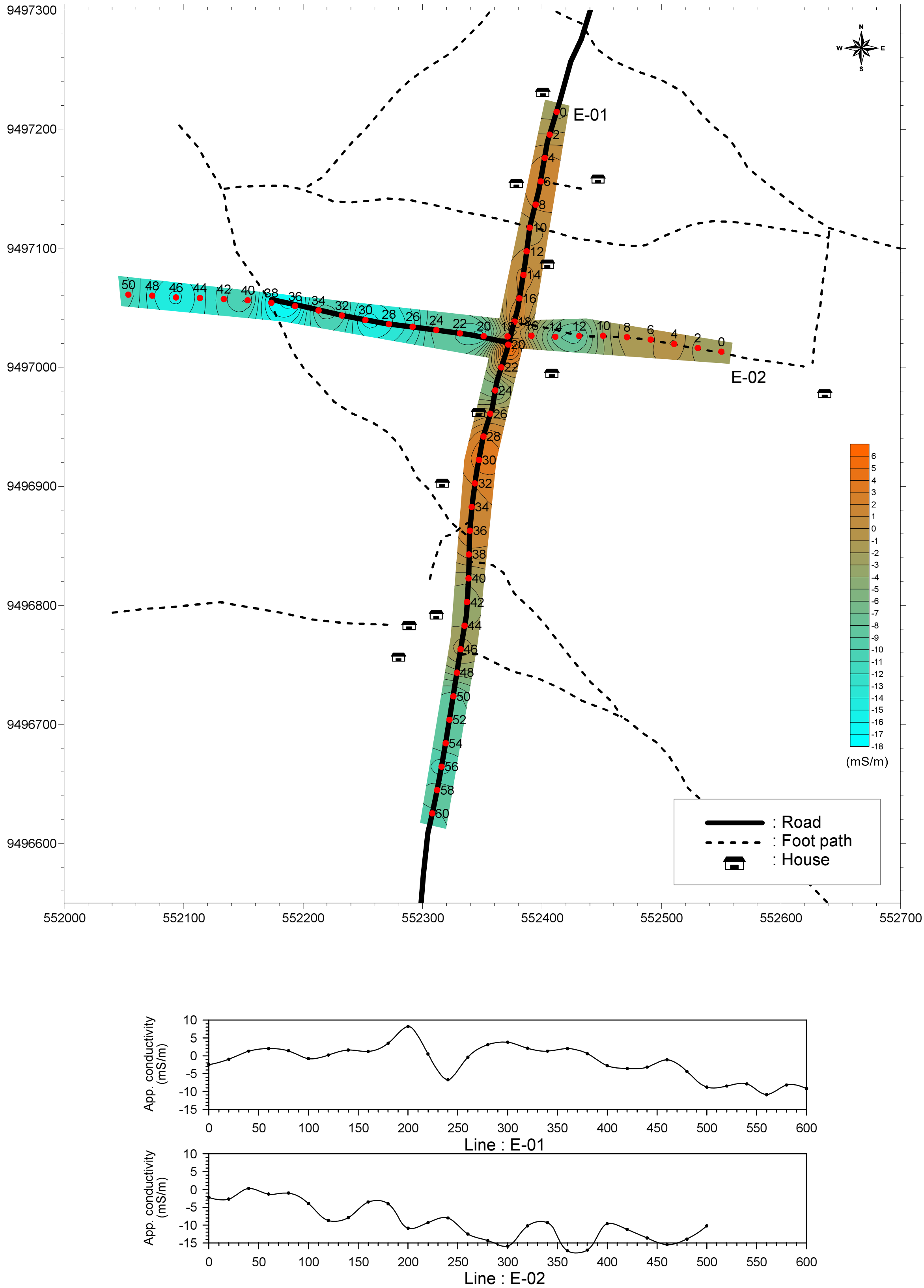
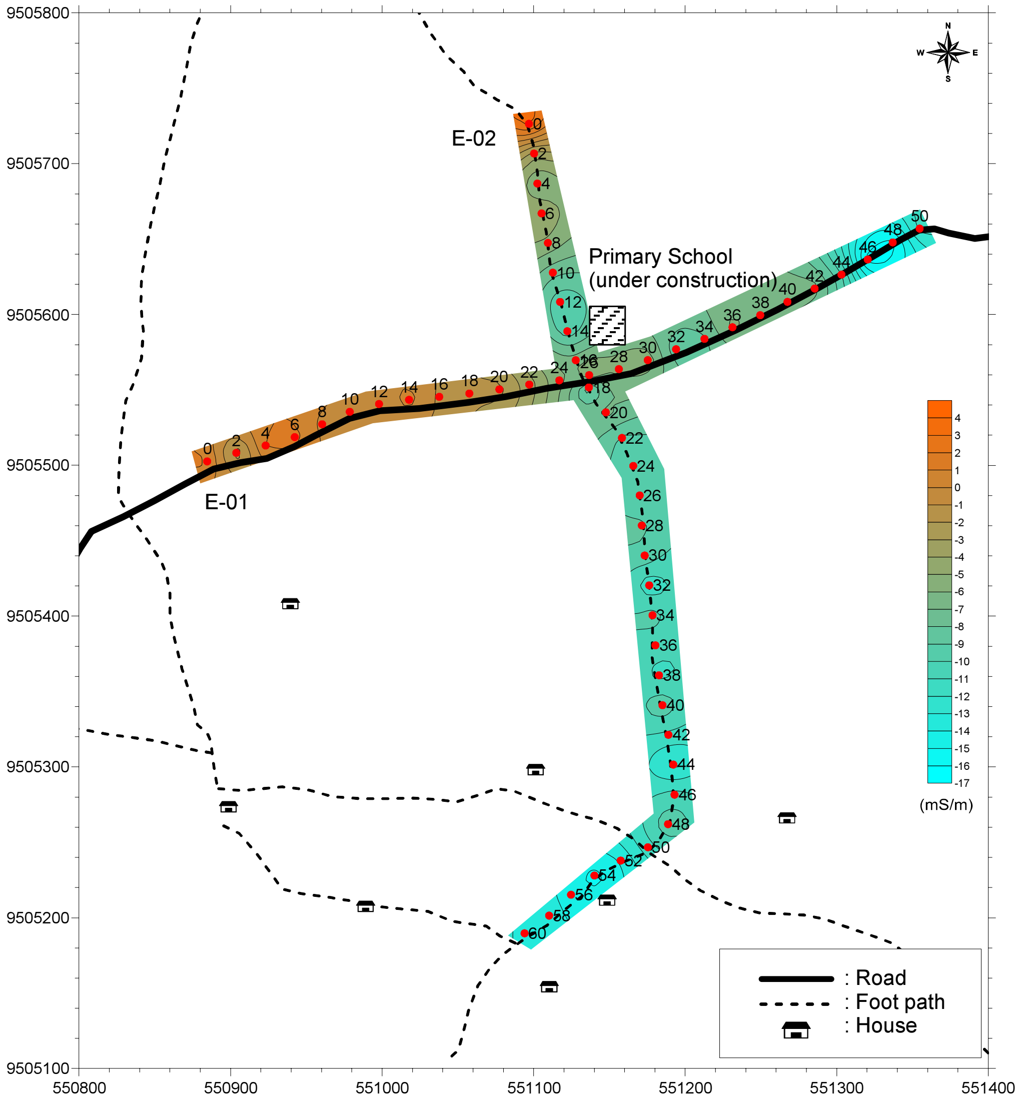


Figure.2.4.4 Geophysical survey results at Kusini-A sub-village in Busomeke village



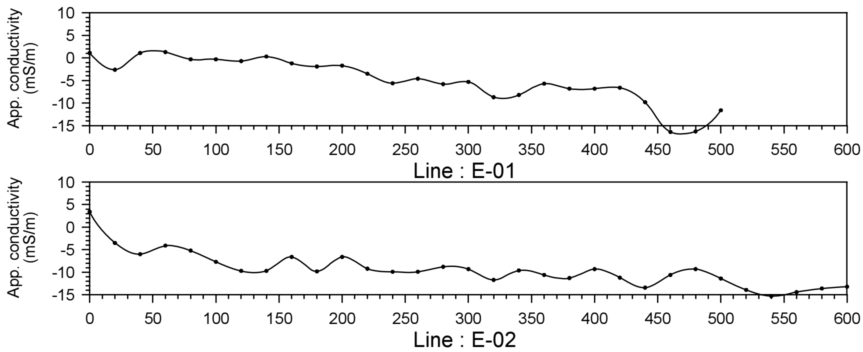


Figure.2.4.5 Geophysical survey results at Bulyawele sub-village in Busomeke village

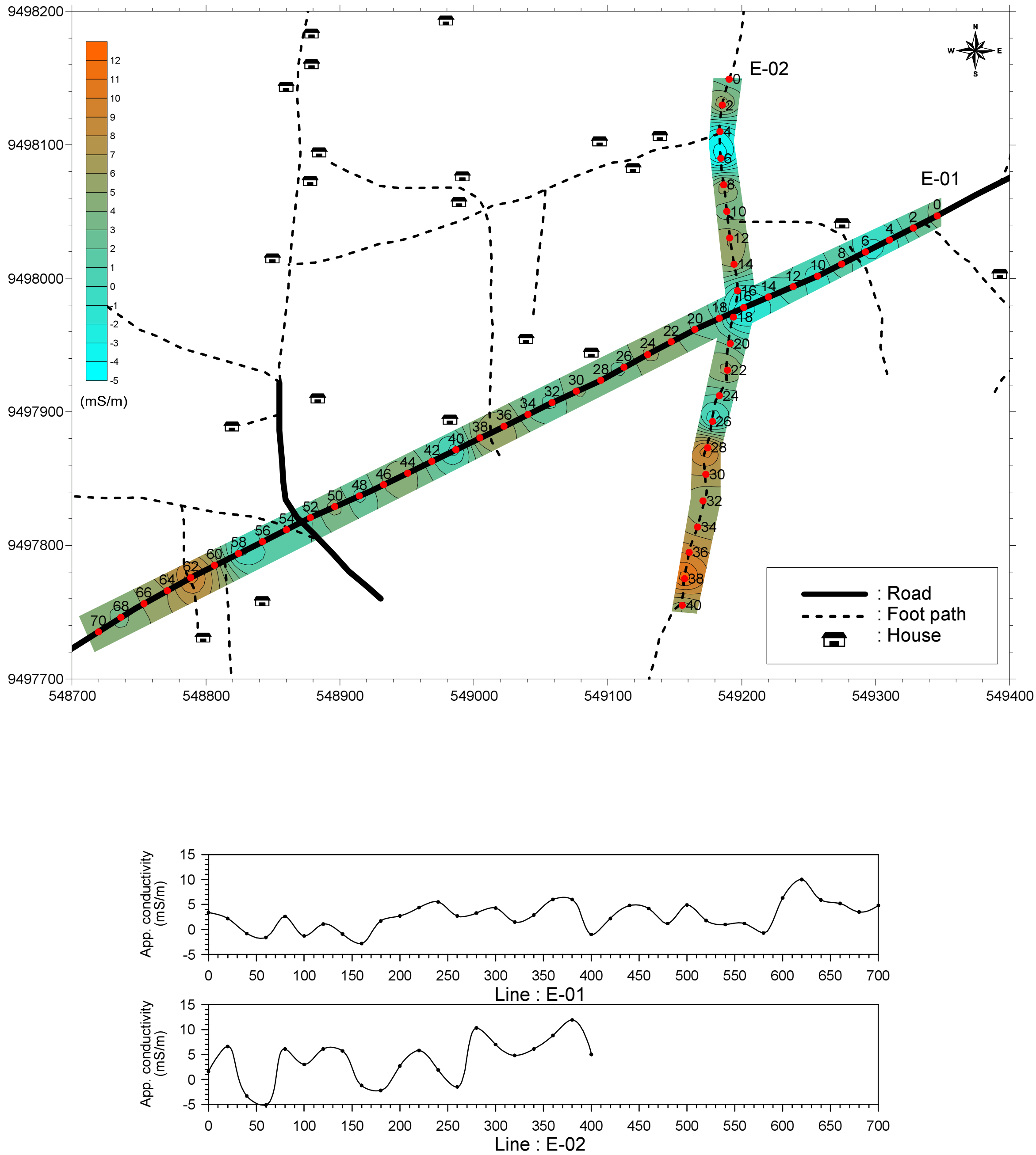
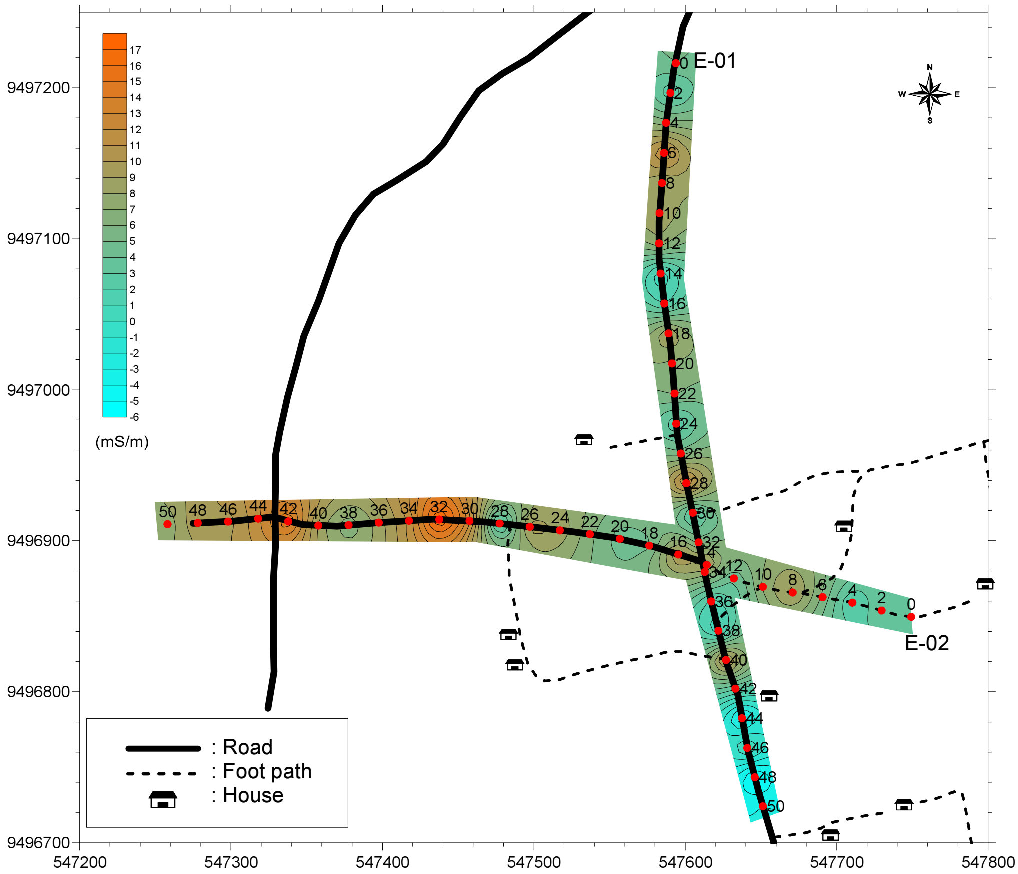


Figure.2.4.6 Geophysical survey results at Kusini Mashariki sub-village in Kalemela village



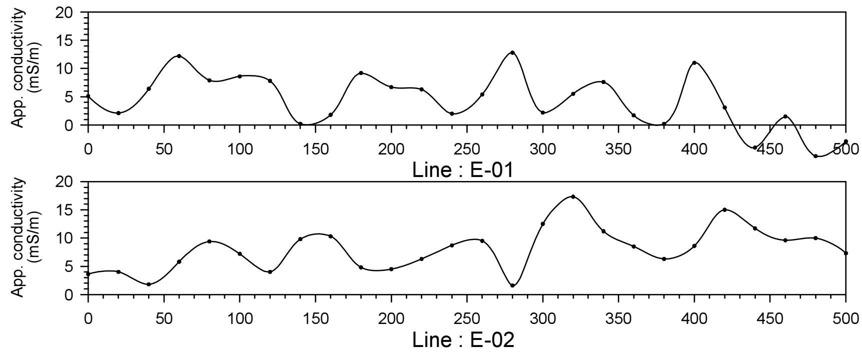


Figure.2.4.7 Geophysical survey results at Kusini sub-village in Kalemela village

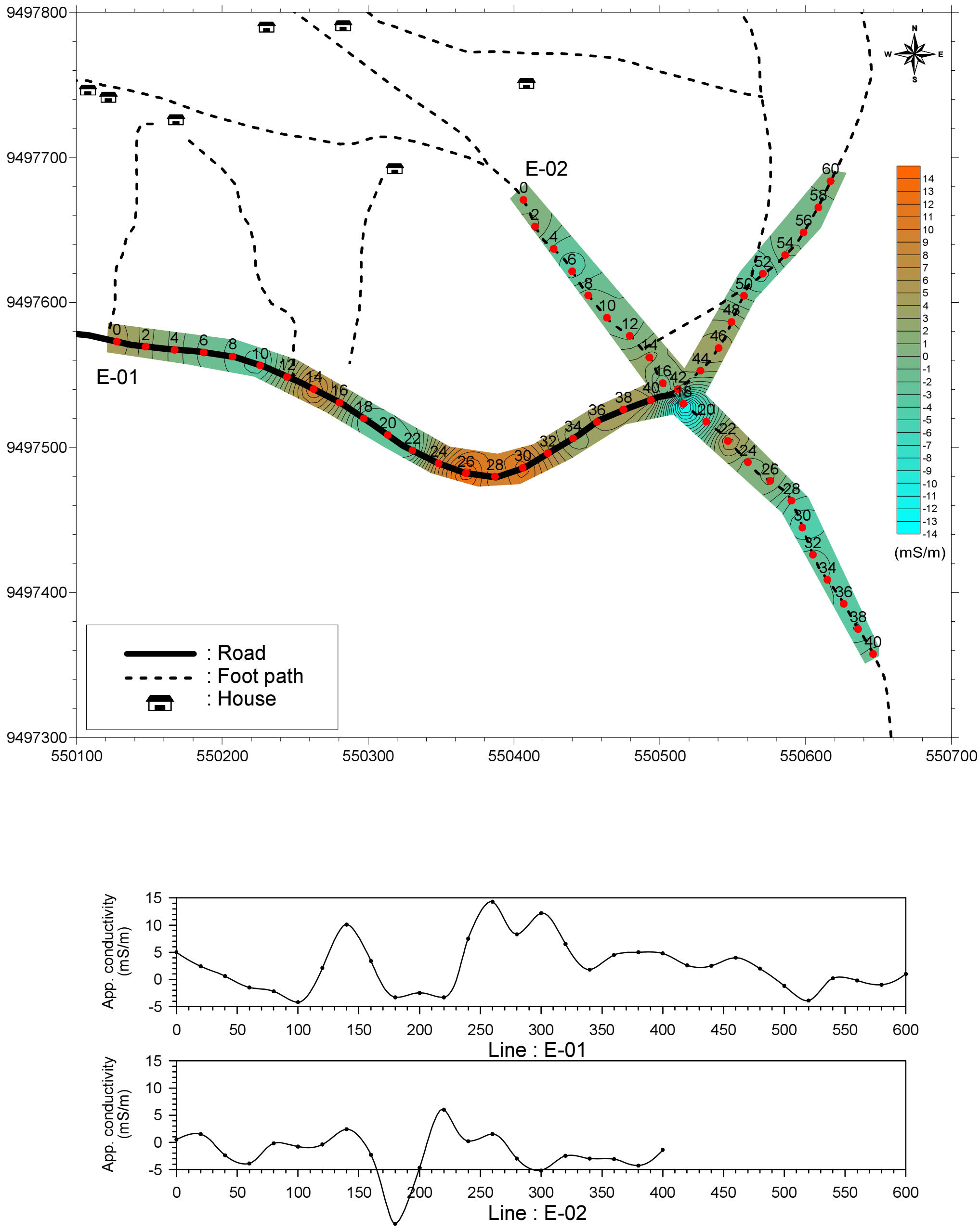


Figure.2.4.8 Geophysical survey results at Mashariki sub-village in Kalemela village

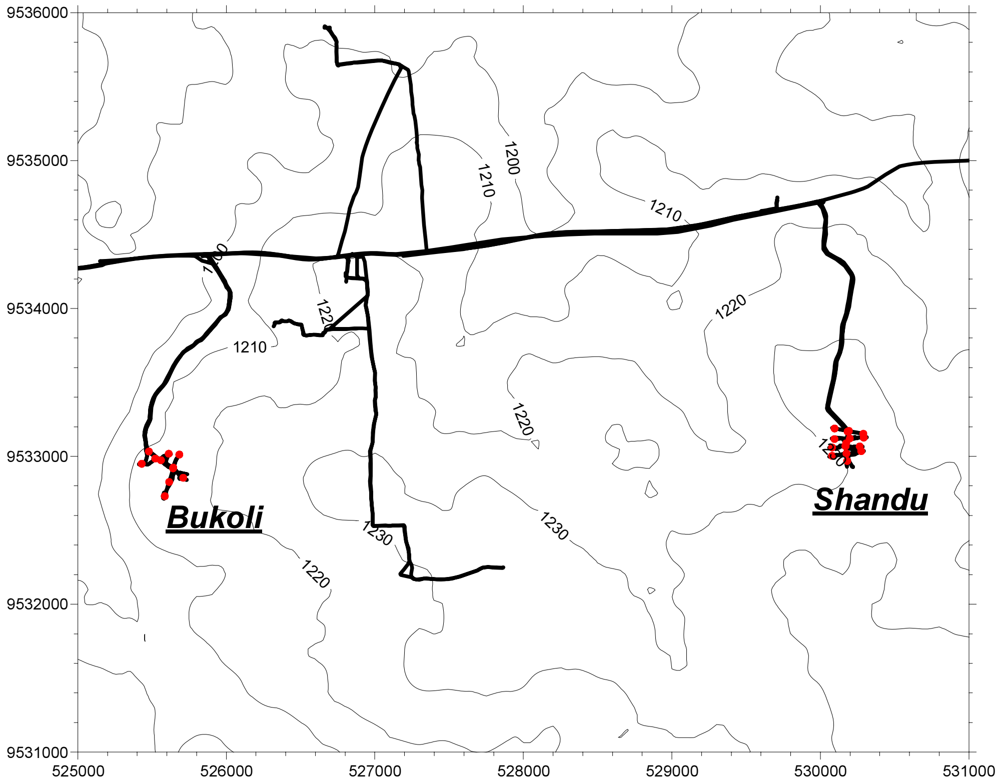


Figure.2.4.9 Geophysical survey location at Kitangili village in Nzega district

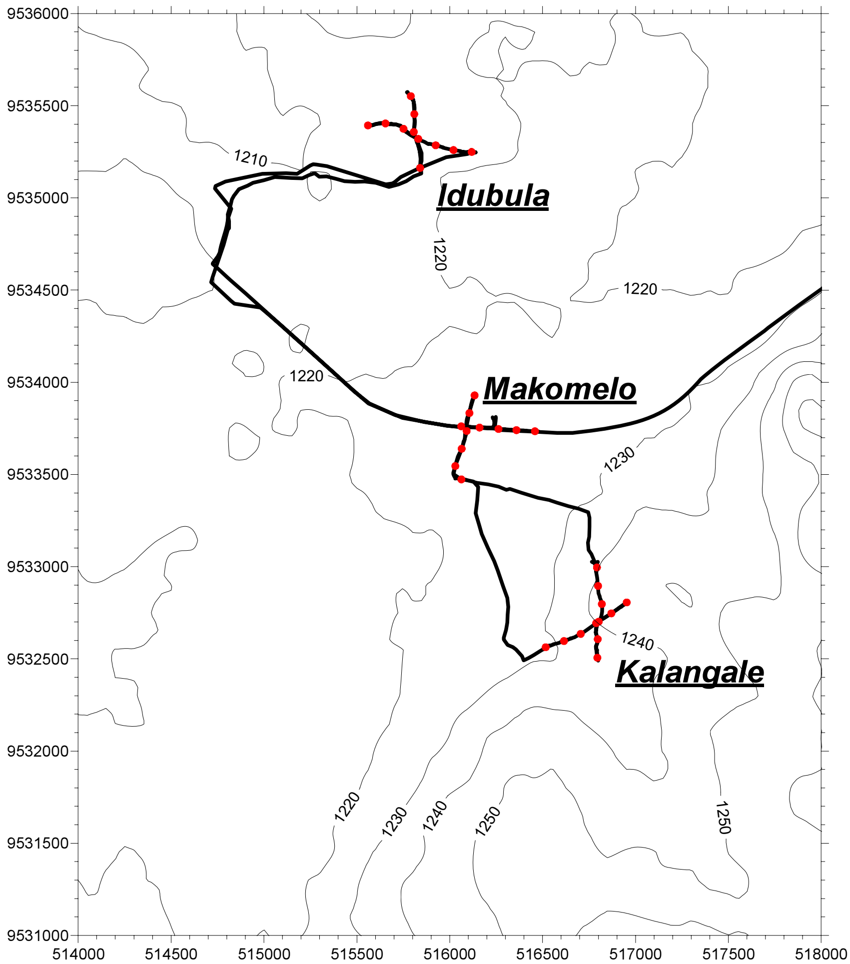


Figure.2.4.10 Geophysical survey location at Makomelo village in Nzega district

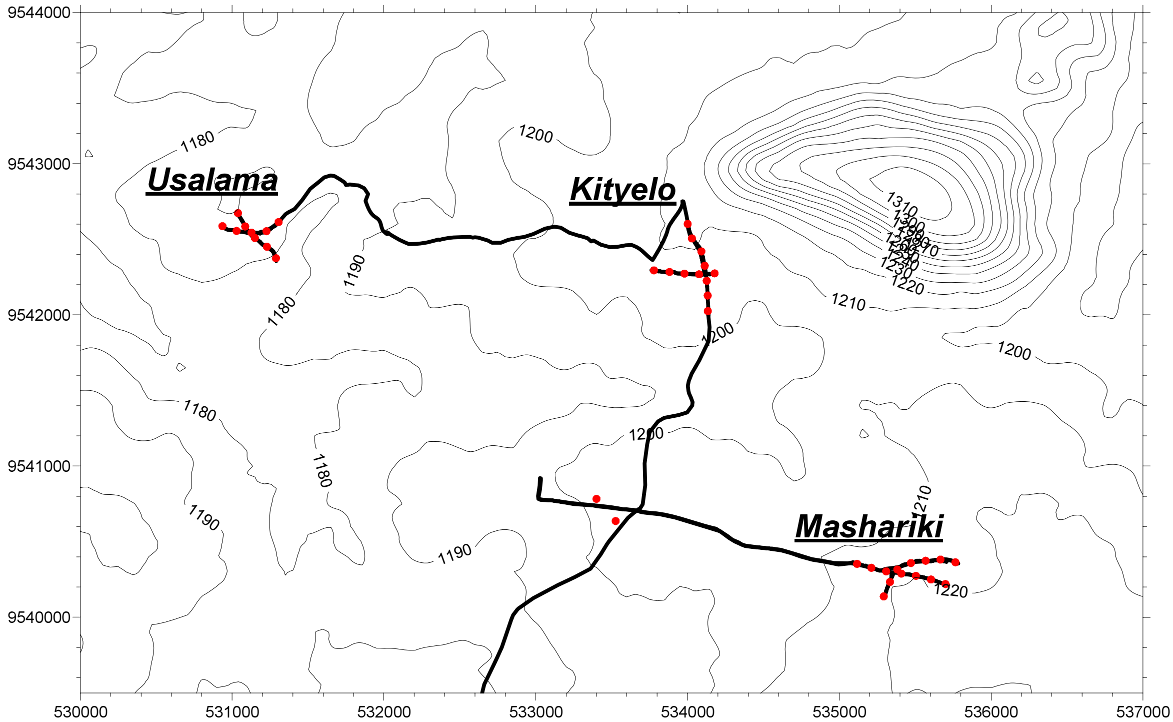


Figure.2.4.11 Geophysical survey location at Wella village in Nzega district

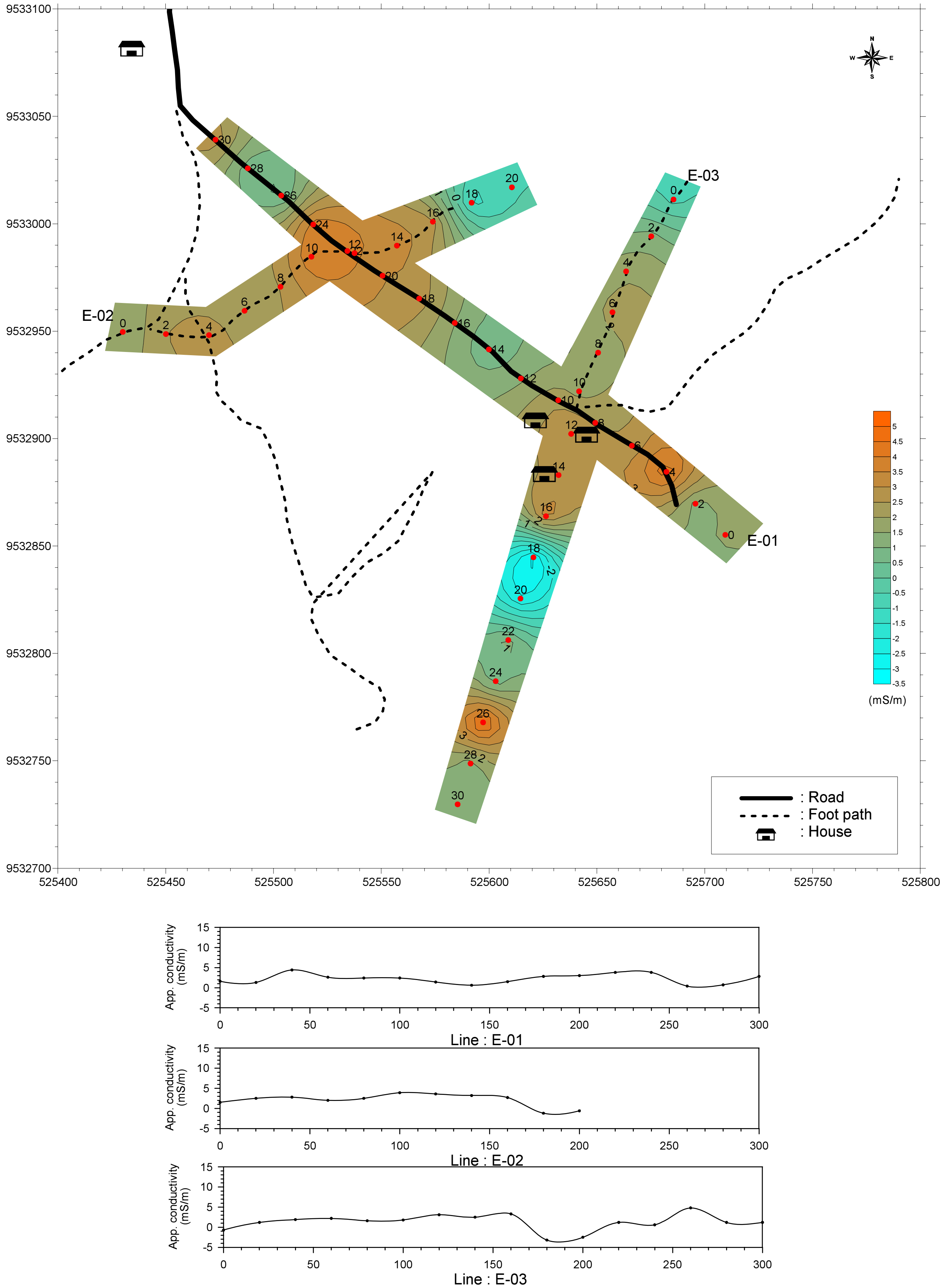


Figure.2.4.12 Geophysical survey results at Bukoli sub-village in Kitangili village

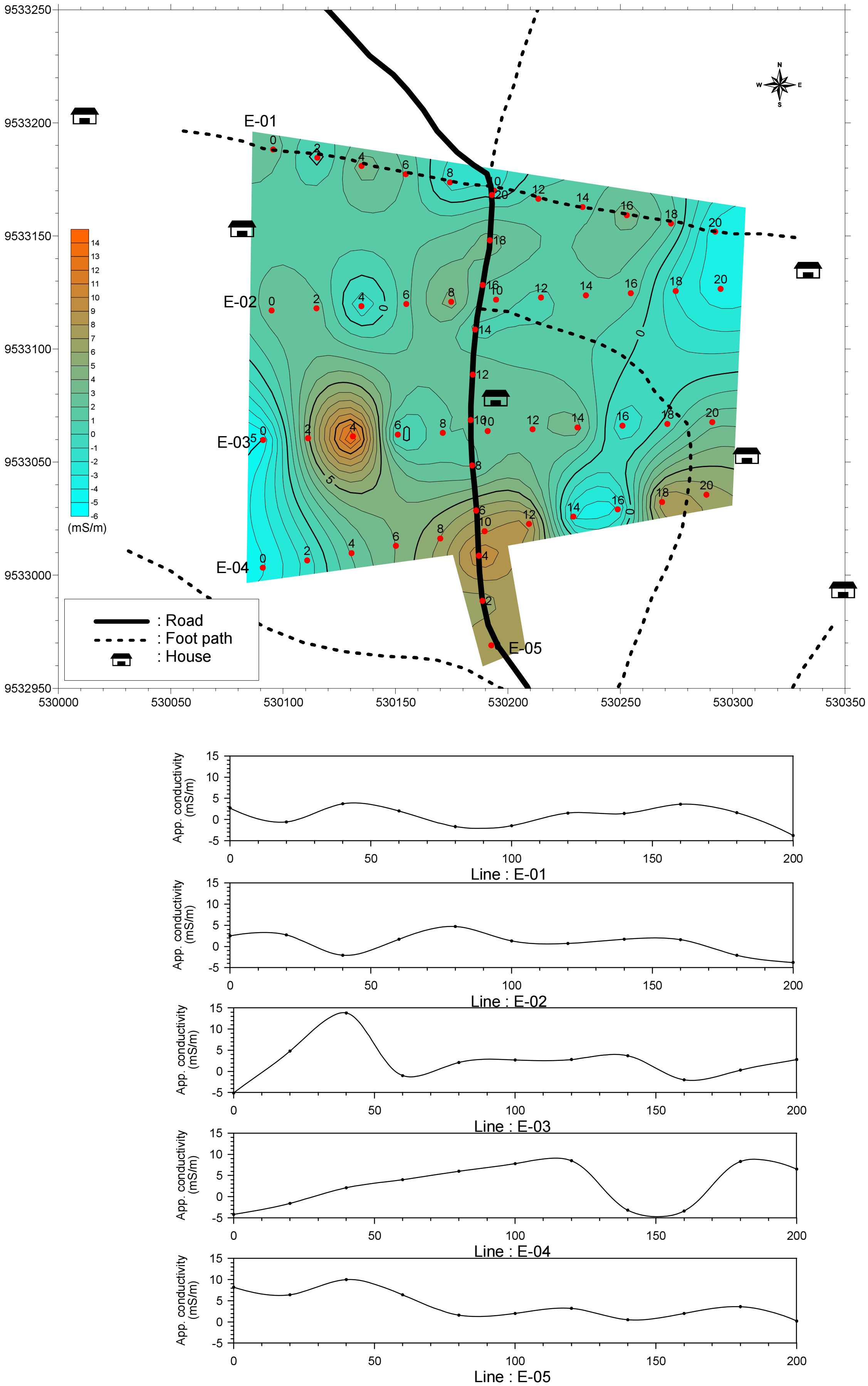


Figure.2.4.13 Geophysical survey results at Shandu sub-village in Kitangili village