

Figure 074-04 Wolaita - Boloso Sore - Gara Godo - Godo

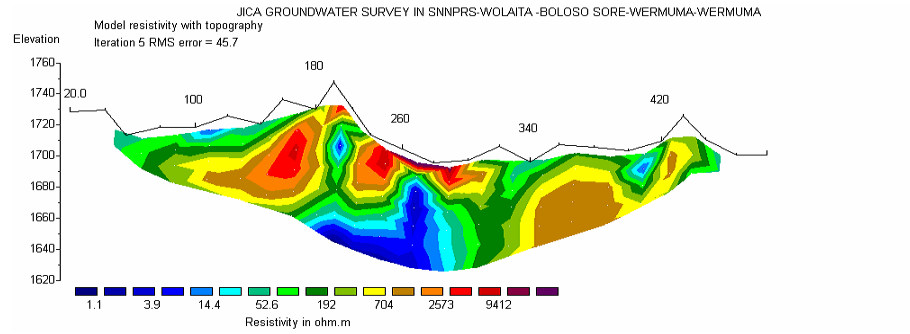


Figure 075-03 Wolaita - Boloso Sore - Wermuma - Wurmuma

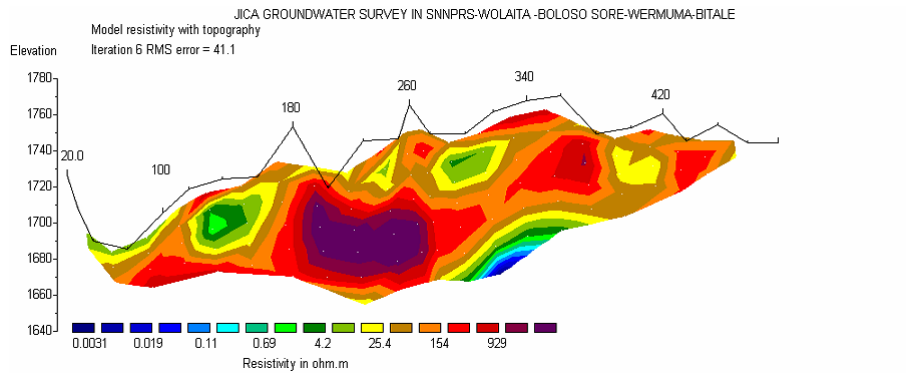


Figure 075-01 Wolaita - Boloso Sore - Wermuma - Betale

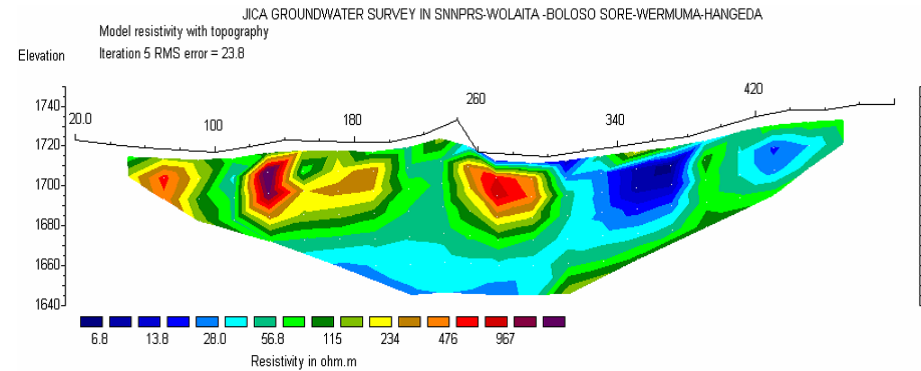


Figure 075-04 Wolaita - Boloso Sore - Wermuma - Hangada

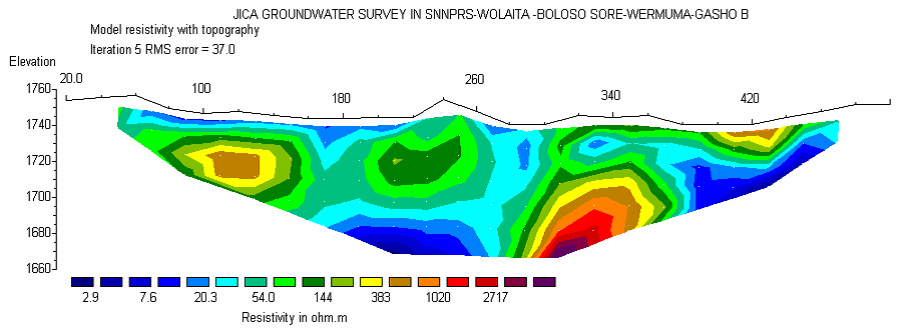


Figure 075-02 Wolaita - Boloso Sore - Wermuma - Gosho Basa

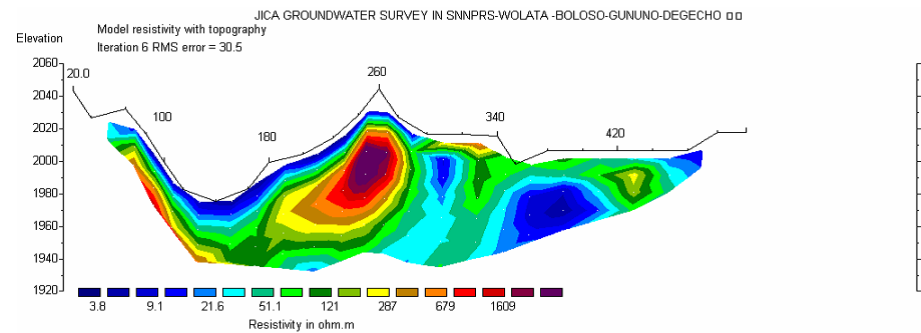


Figure 076-01 Wolaita - Boloso Sore - Gununo - Gegecho

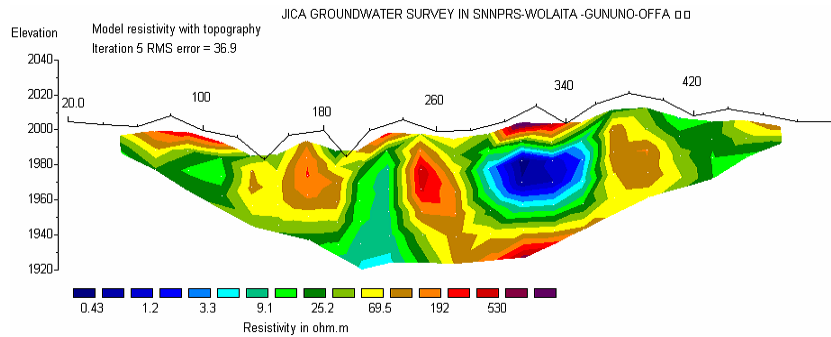


Figure 076-02 Wolaita - Boloso Sore – Gununo - Offa

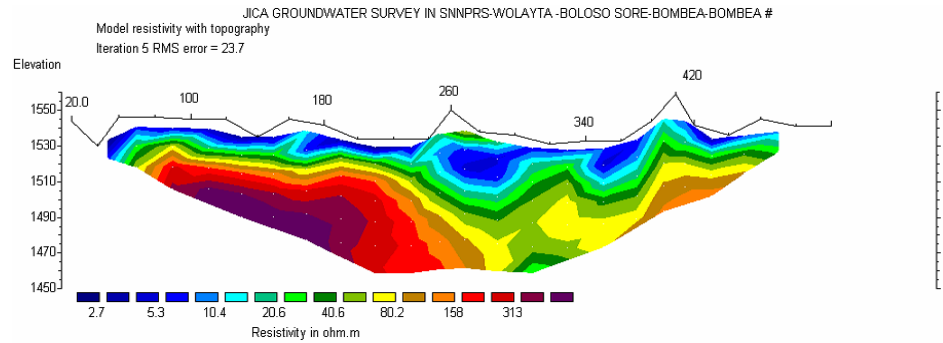


Figure 077-02 Wolaita - Boloso Sore – Bomebea - Bombei #2

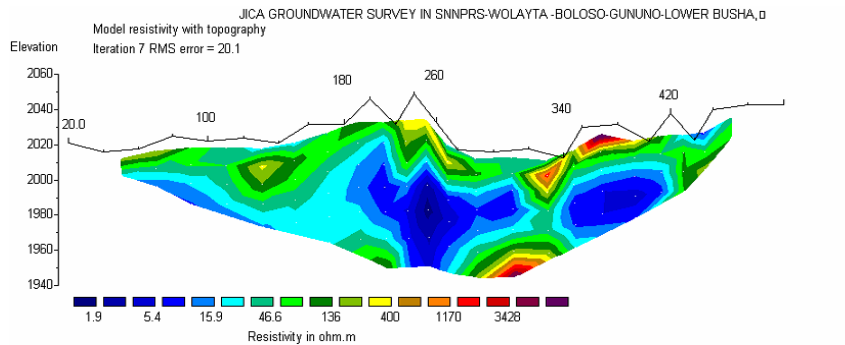


Figure 076-03 Wolaita - Boloso Sore – Gununo - Lower Busha

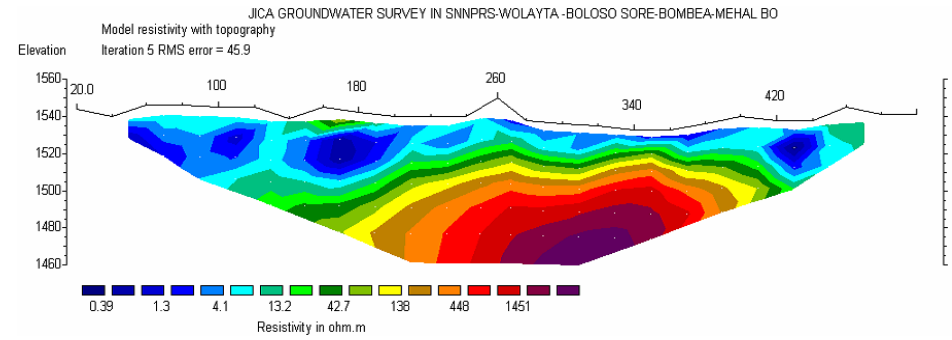


Figure 077-03 Wolaita - Boloso Sore – Bomebea - Mahal Bombei

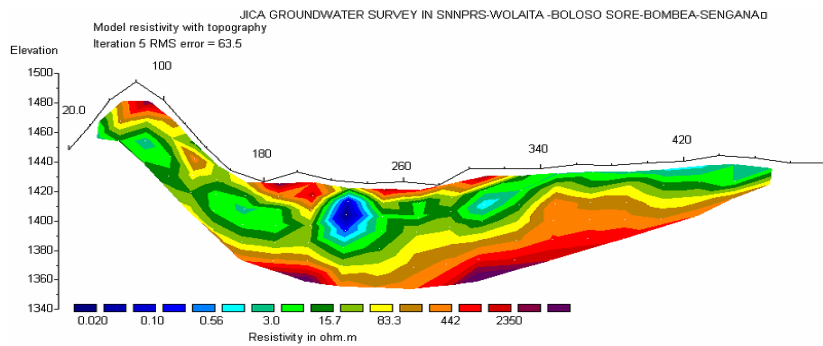


Figure 077-01 Wolaita - Boloso Sore – Bomebea - Sunganna

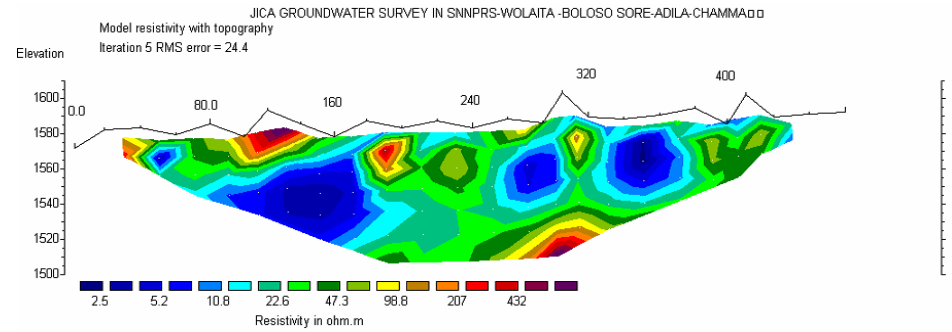


Figure 078-01 Wolaita - Boloso Sore – Adila - Chamma

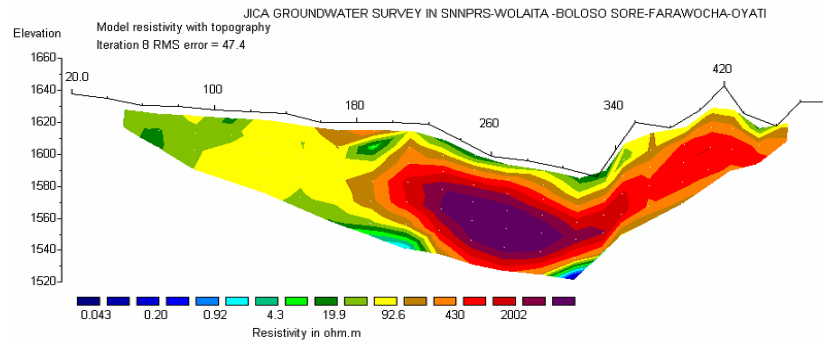


Figure 079-02 Wolaita - Boloso Sore – Farawocha - Oyati

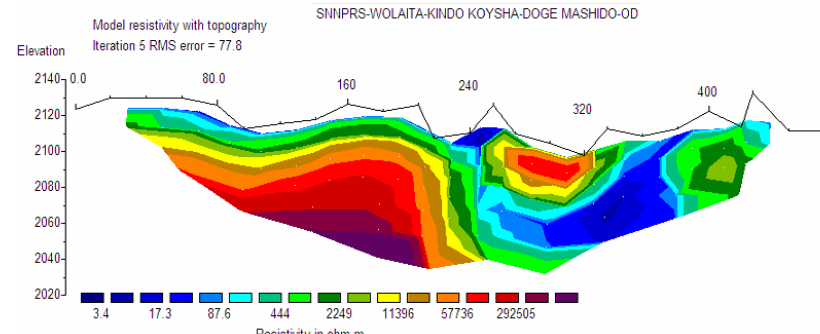


Figure 083 Wolaita - Kindo Koyesha – Doge Mashedo - Odoro

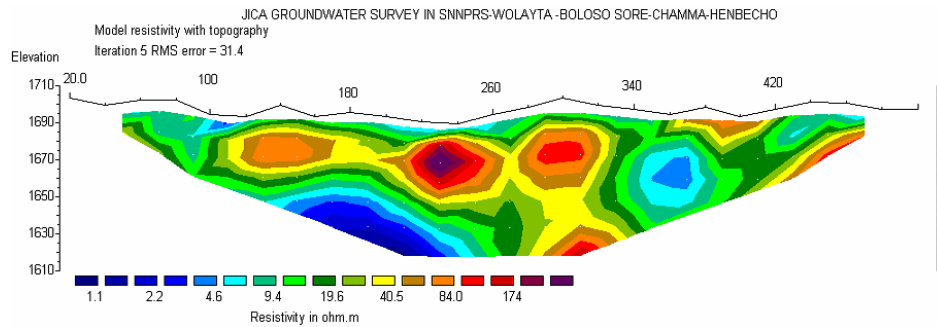


Figure 080-03 Wolaita - Boloso Sore - Chama Henbecho - Koisha Manisa

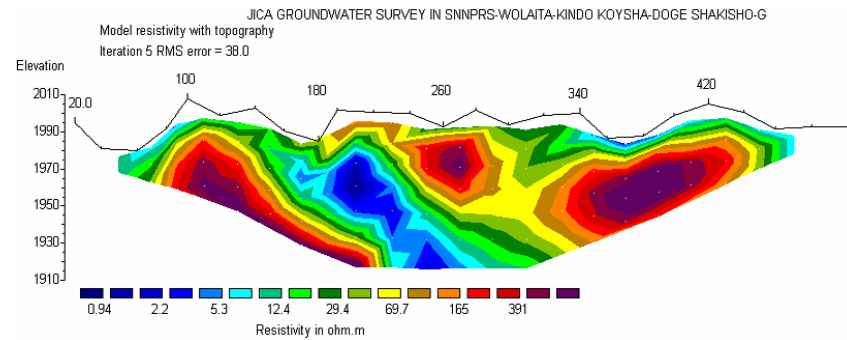


Figure 084 Wolaita - Kindo Koyesha – Doge Shakisho - Gadala

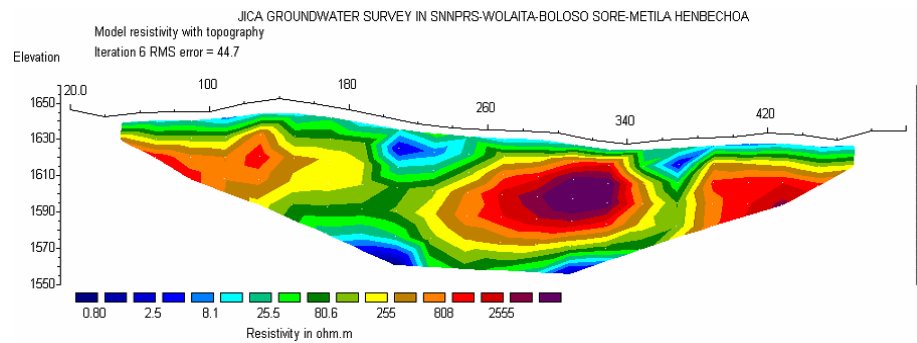


Figure 081-01 Wolaita - Boloso Sore - Matila Hibeche - Mahal Matala

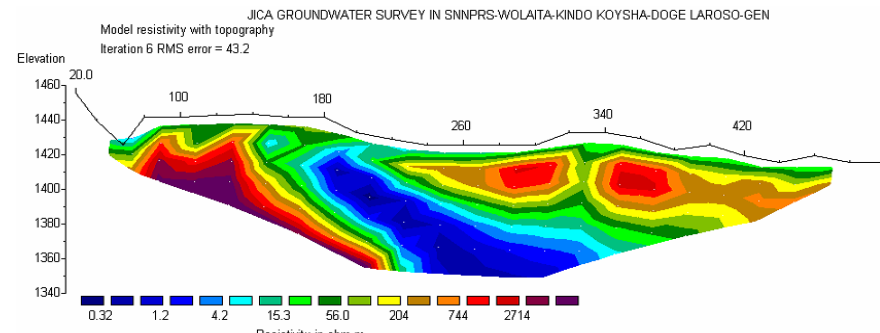


Figure 085 Wolaita - Kindo Koyesha – Doge Larosa - Genbela

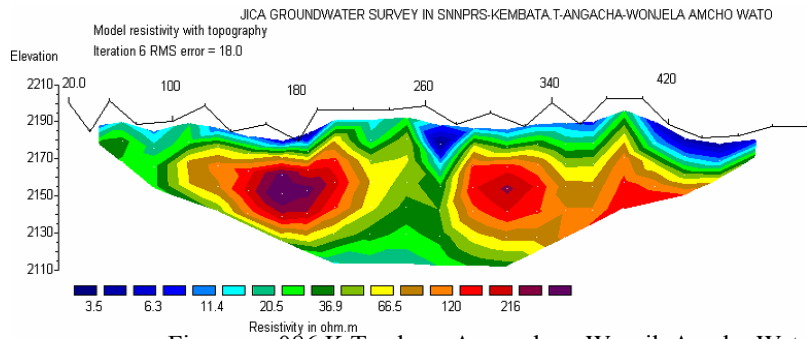


Figure 086 K.Tembar - Anegacha – WenejlaAmcho Wato -

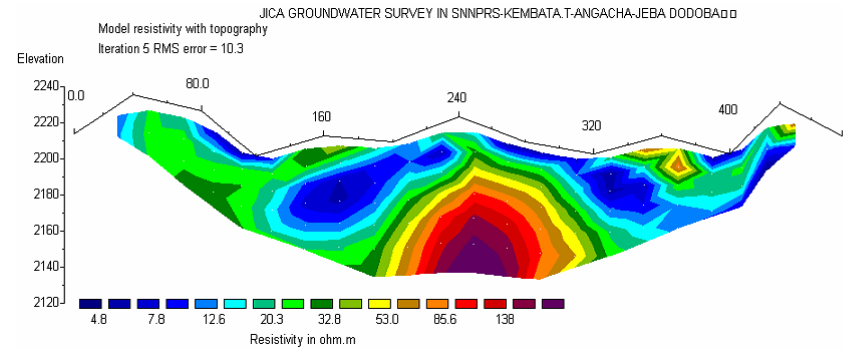


Figure 090 K.Tembar - Anegacha – Jeba Dodoba -

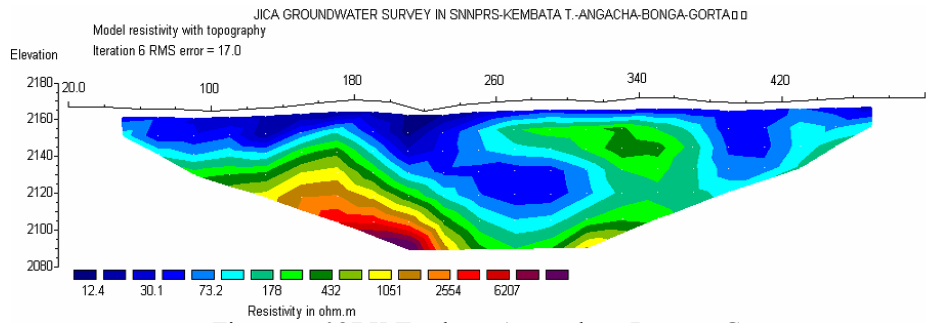


Figure 087 K.Tembar - Anegacha – Bonga - Gorta

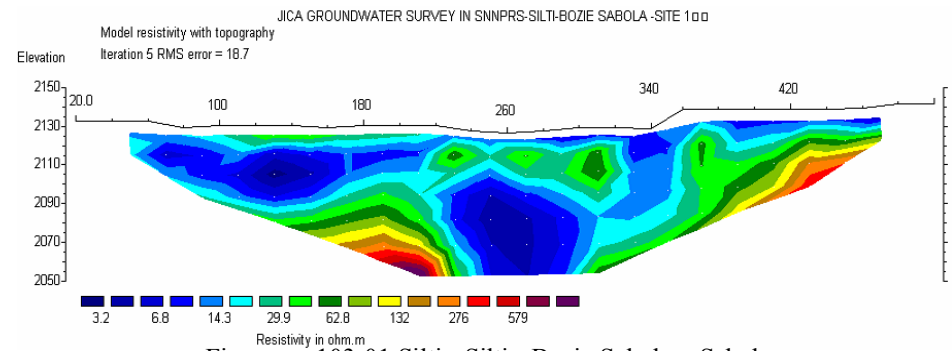


Figure 103-01 Silti - Silti - Bozie Sabola – Sabola

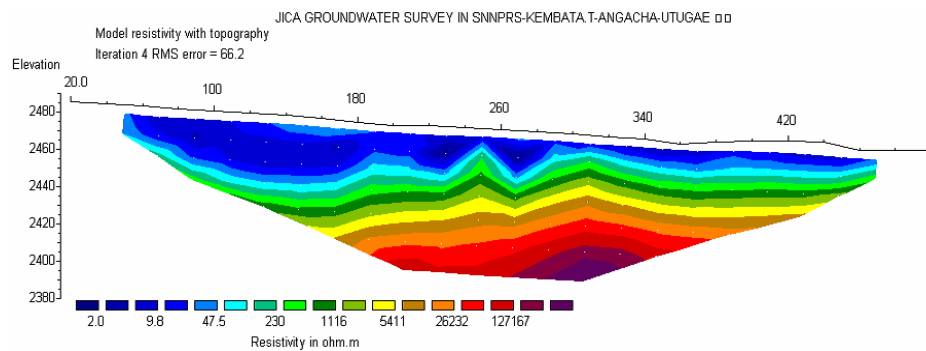


Figure 089 K.Tembar - Anegacha – Uetuge - Utugae

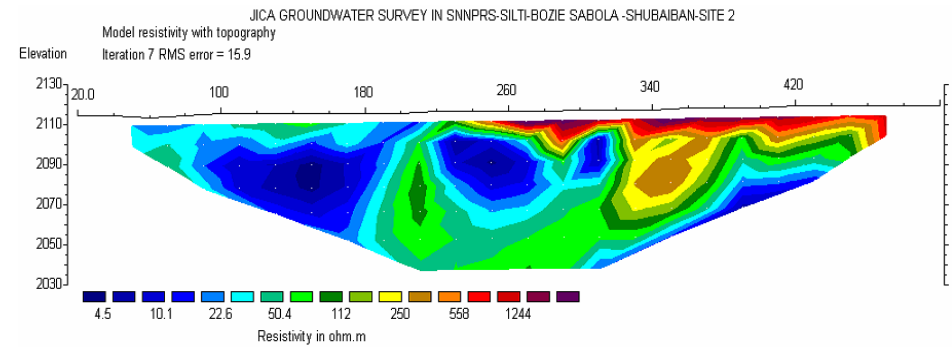


Figure 103-02 Silti - Silti - Bozie Sabola – Shebaiban

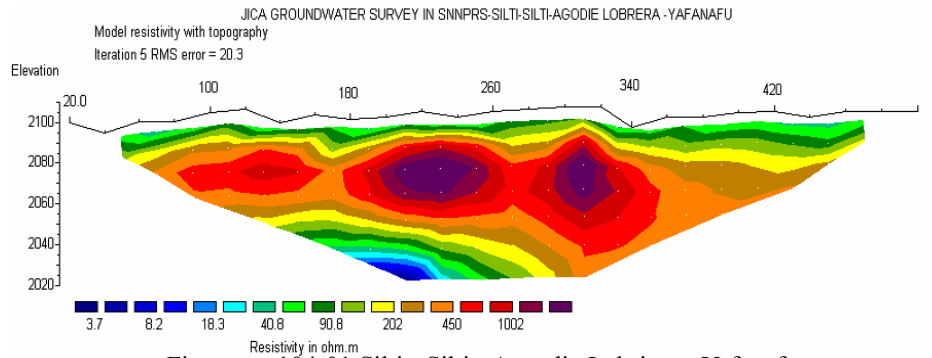


Figure 104-01 Silti - Silti - Aegodie Lobriera - Yafanafu

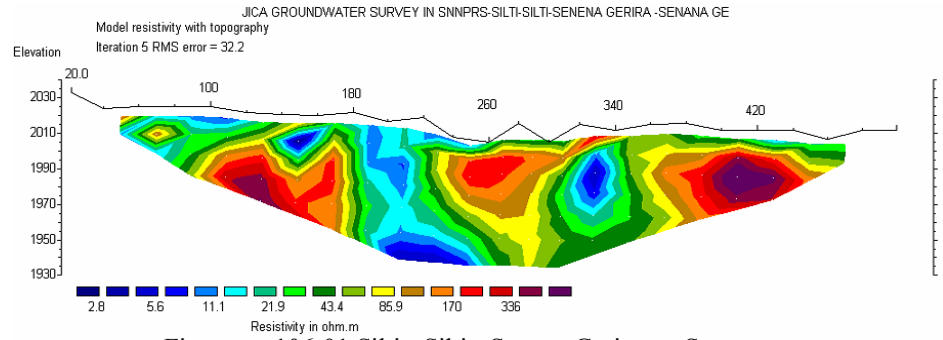


Figure 106-01 Silti - Silti - Senene Gerierar - Senena gerera

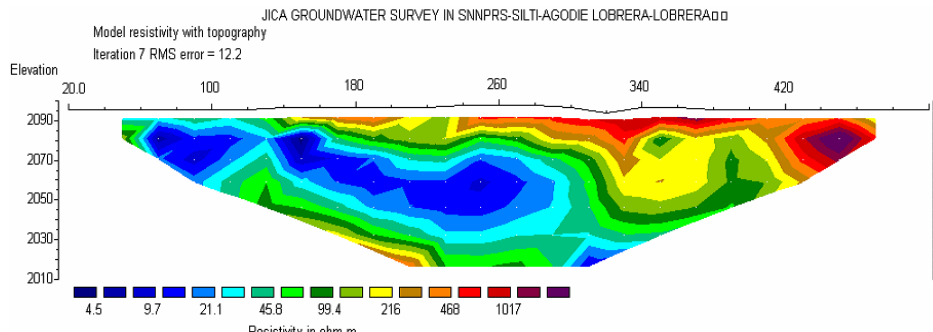


Figure 104-02 Silti - Silti - Aegodie Lobriera - Lobrere

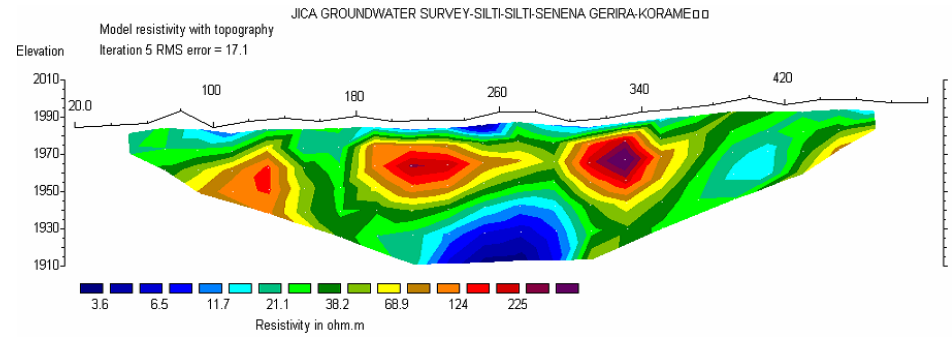


Figure 106-02 Silti - Silti - Senene Gerierar - Korame

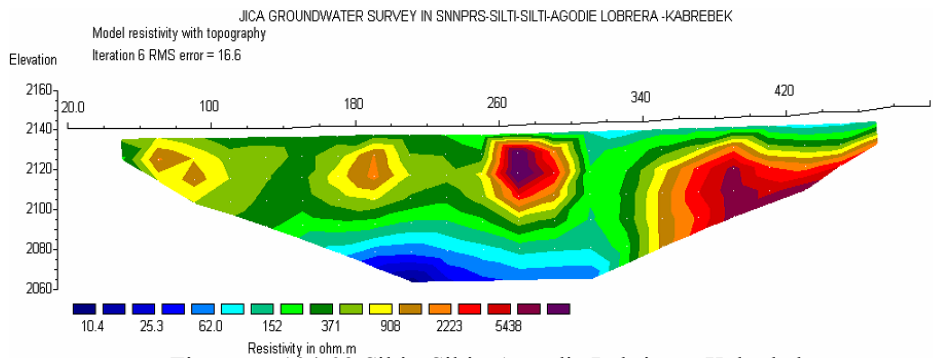


Figure 104-03 Silti - Silti - Aegodie Lobriera - Kabrabaka

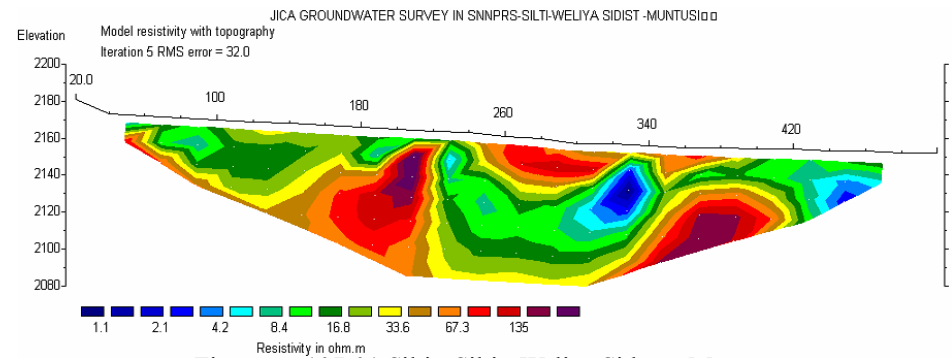


Figure 107-01 Silti - Silti - Weliya Sidest - Muntuso

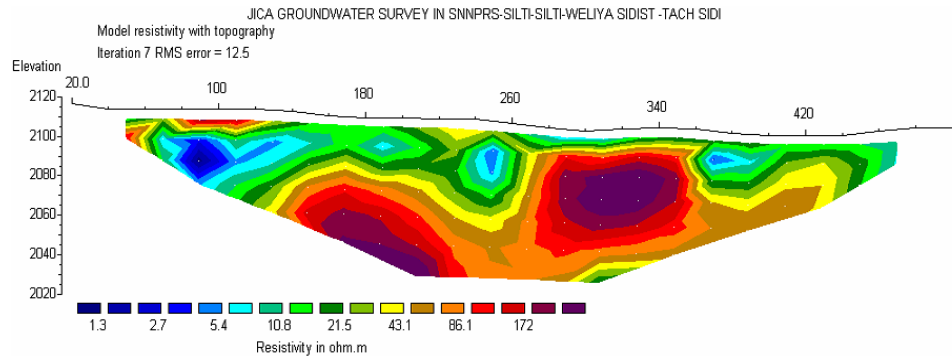


Figure 107-02 Silti - Silti - Weliya Sidest - Tash

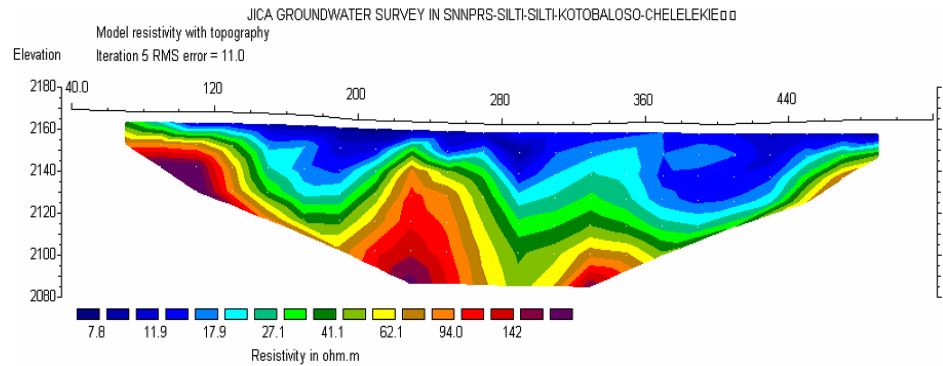


Figure 108-03 Silti - Silti - Koto Balosd - Chalalaka

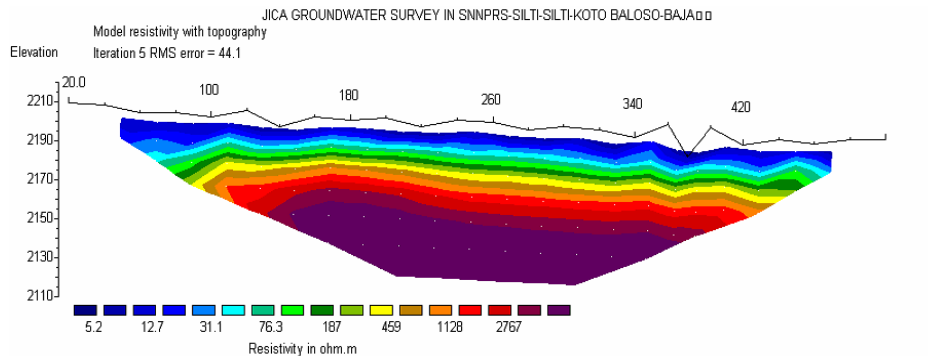


Figure 108-01 Silti - Silti - Koto Balosd - Baja

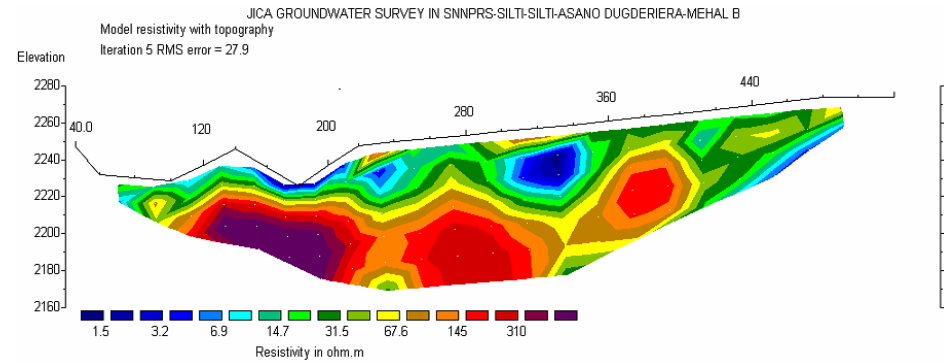


Figure 109-01 Silti - Silti - Asano Degderiea - Mahal Baja #1

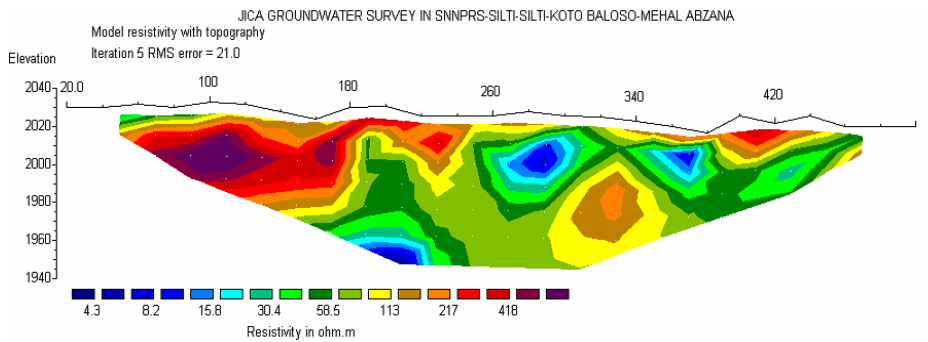


Figure 108-02 Silti - Silti - Koto Balosd - Mahal Abzana

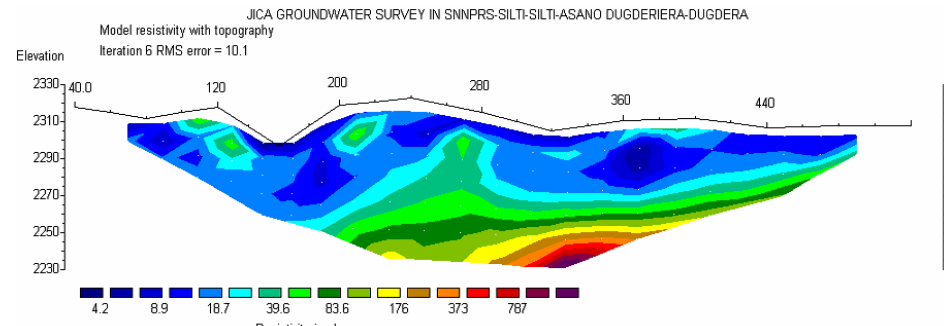


Figure 109-02 Silti - Silti - Asano Degderiea - Dugudarera

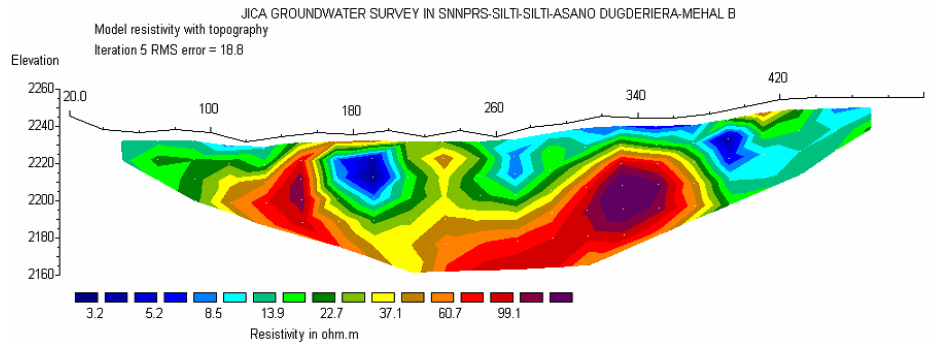


Figure 109-03 Silti - Silti - Asano Degderiea - Mahal Baja #2

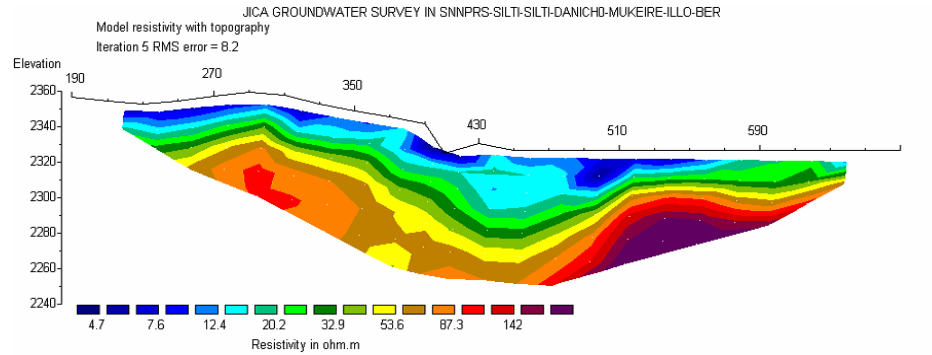


Figure 111-02 Silti - Silti - Daniecho Mukerie - Ellobal

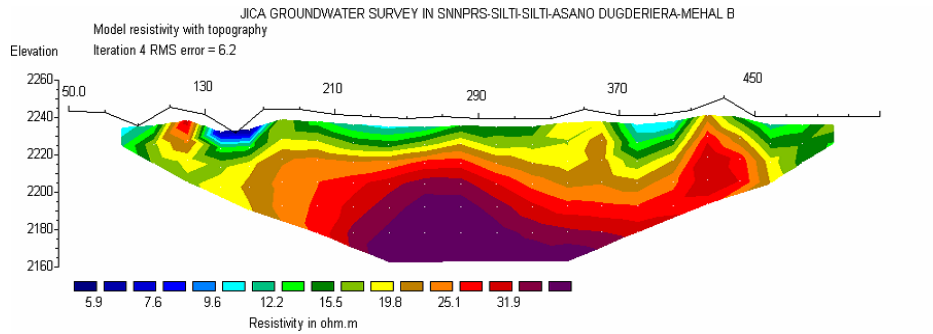


Figure 109-04 Silti - Silti - Asano Degderiea - Mahal Baja #3

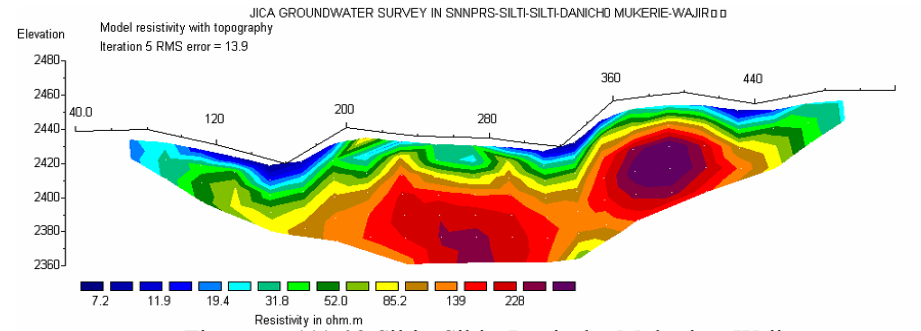


Figure 111-03 Silti - Silti - Daniecho Mukerie - Wajir

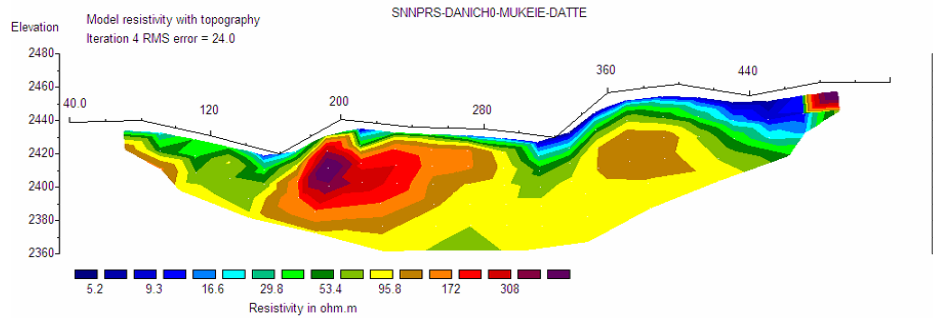


Figure 111-01 Silti - Silti - Daniecho Mukerie - Daate

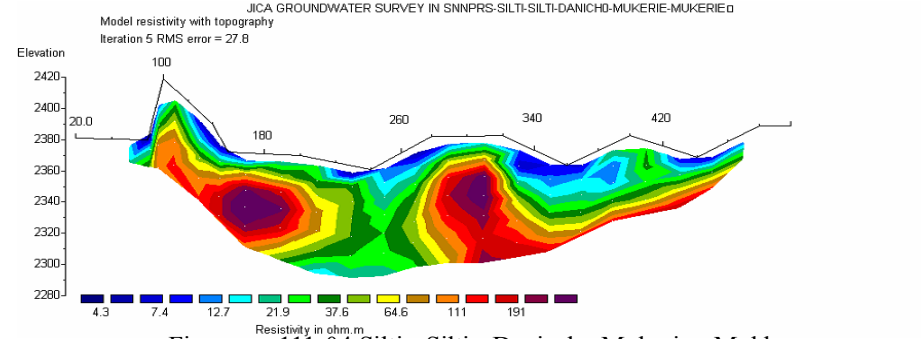


Figure 111-04 Silti - Silti - Daniecho Mukerie - Mukkare

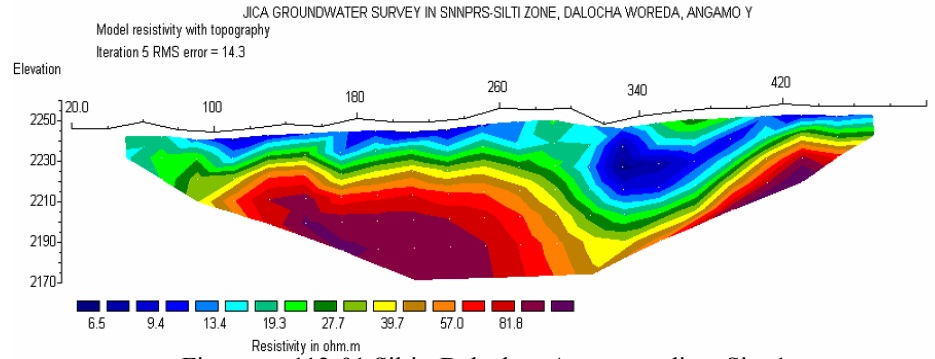


Figure 112-01 Silti - Dalocha - Angamoyedie – Site 1

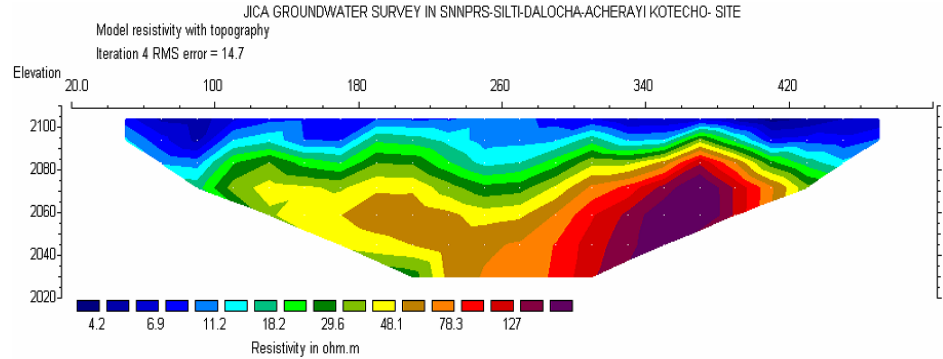


Figure 113-02 Silti - Dalocha - Acherayi Konecho - Site 2

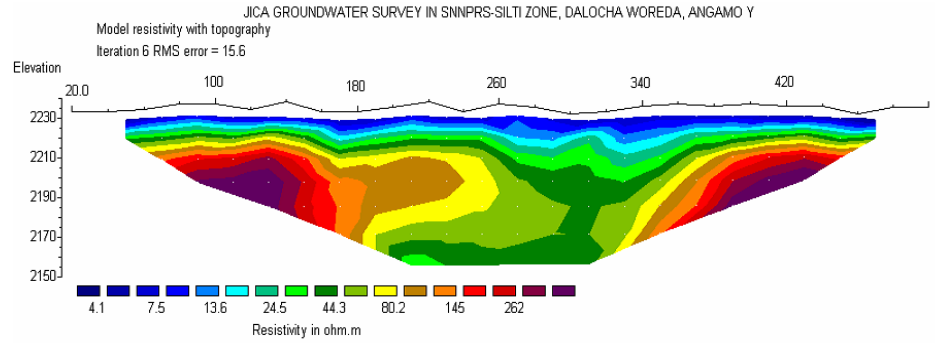


Figure 112-02 Silti - Dalocha - Angamoyedie - Site 2

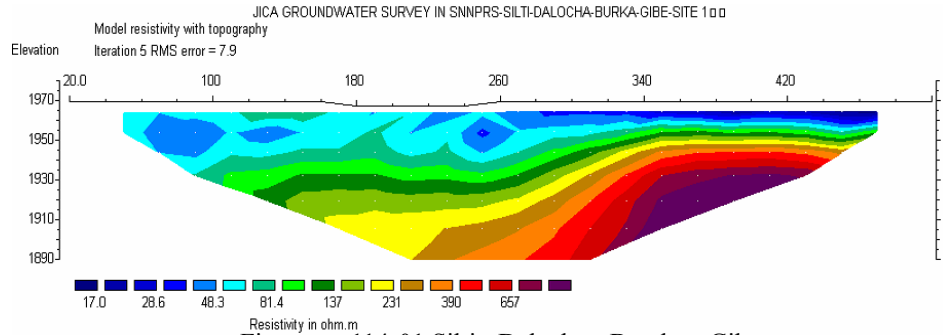


Figure 114-01 Silti - Dalocha - Bureka - Gibe

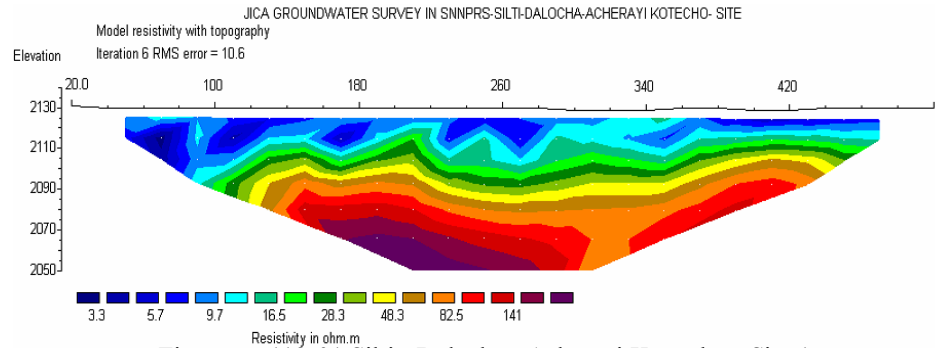


Figure 113-01 Silti - Dalocha - Acherayi Konecho - Site 1

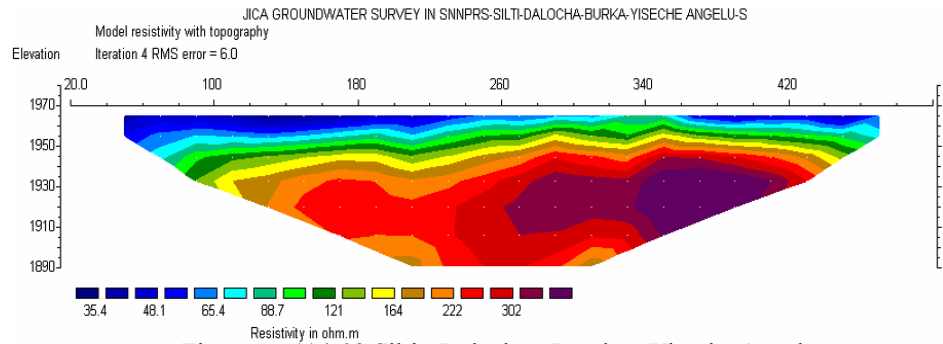


Figure 114-02 Silti - Dalocha - Bureka - Yiseche Angelu



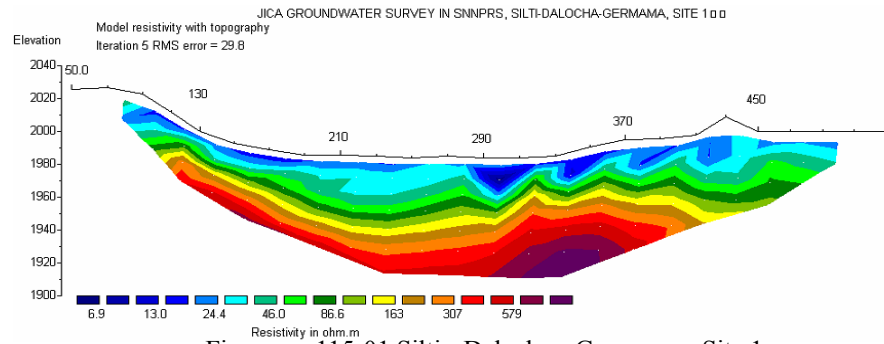


Figure 115-01 Silti - Dalocha - Germama - Site 1

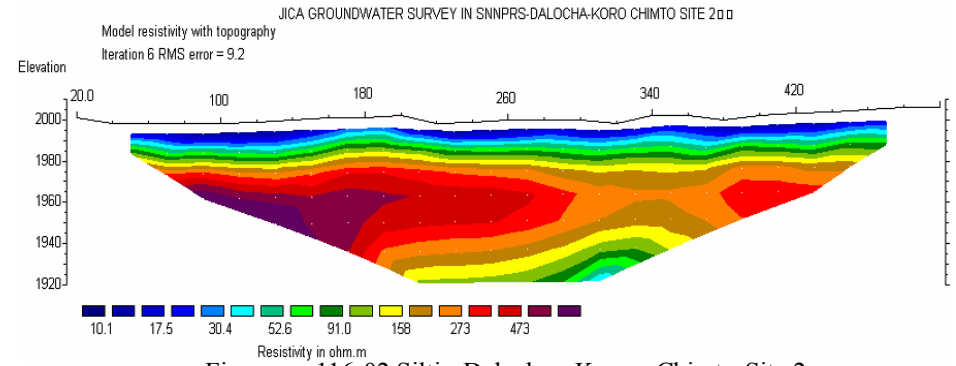


Figure 116-02 Silti - Dalocha - Koro - Chimt - Site 2

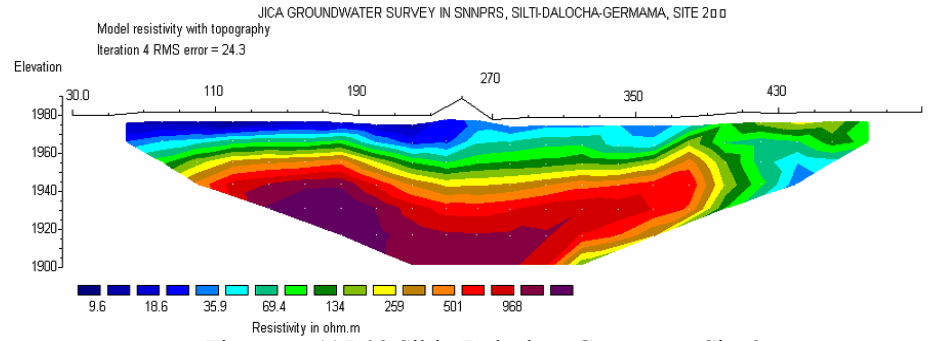


Figure 115-02 Silti - Dalocha - Germama - Site 2

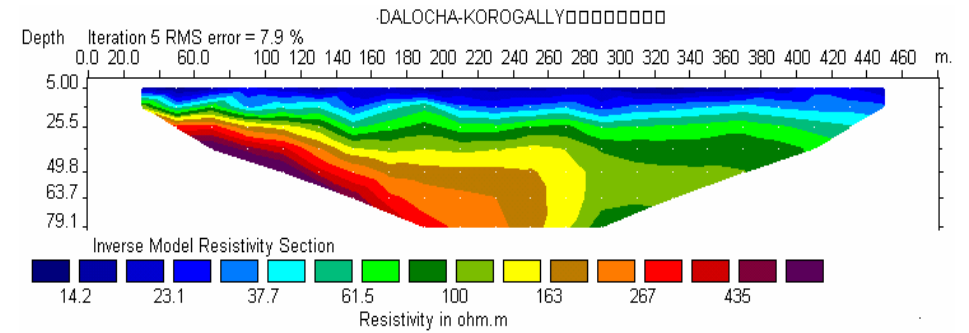


Figure 117-01 Silti - Dalocha - Korogalay - Site 1

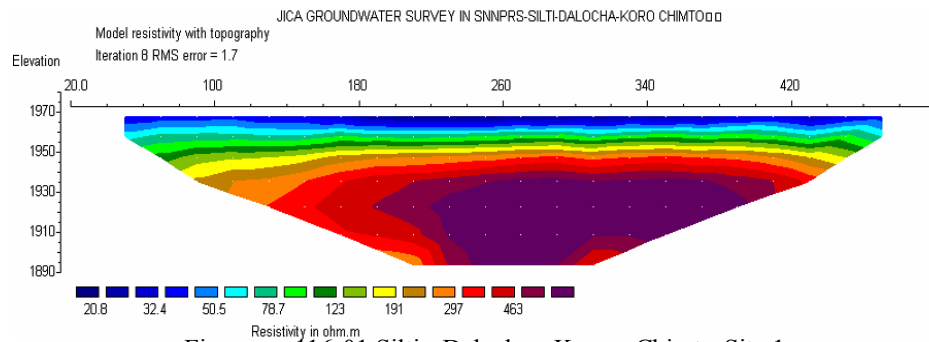


Figure 116-01 Silti - Dalocha - Koro - Chimt - Site 1

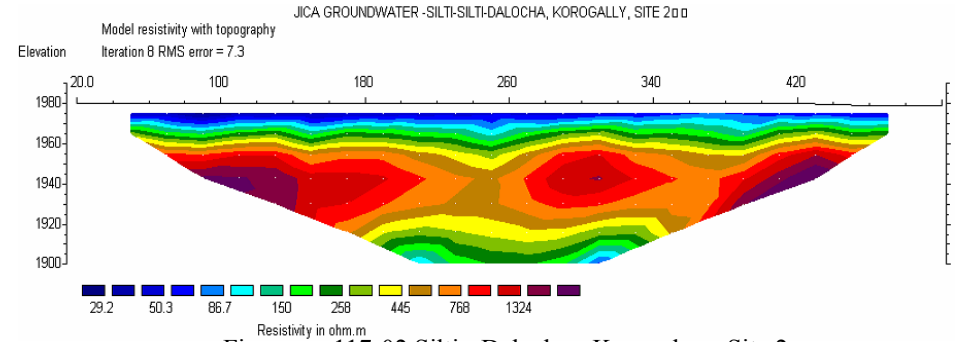


Figure 117-02 Silti - Dalocha - Korogalay - Site 2

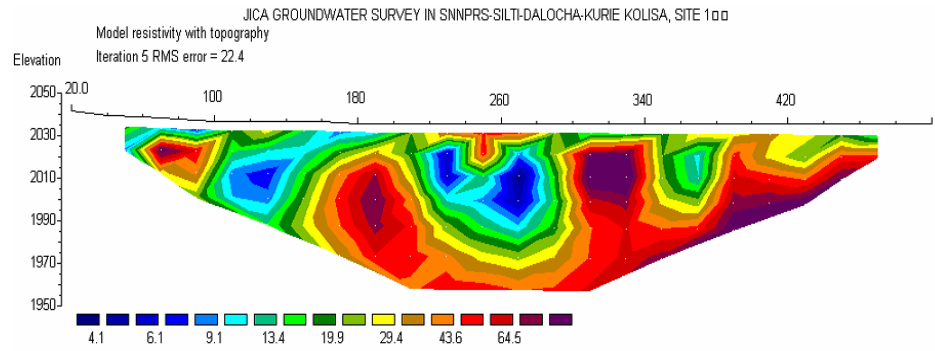


Figure 118-01 Silti - Dalocha - Kura Kolisa - Site 1

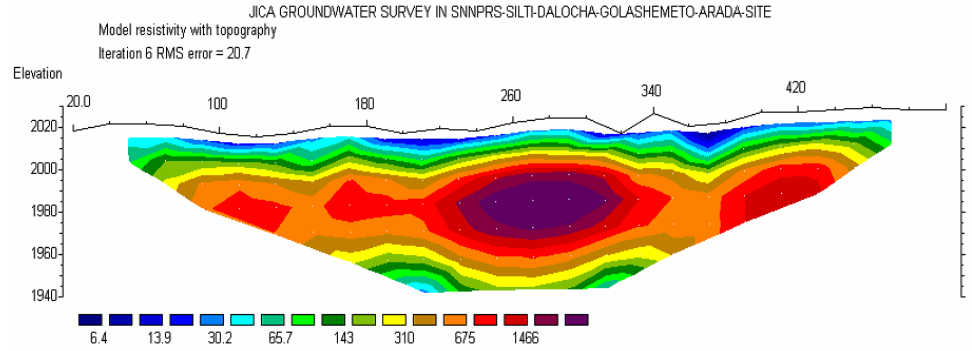


Figure 119-02 Silti - Dalocha - Golana Shemeto - Arada

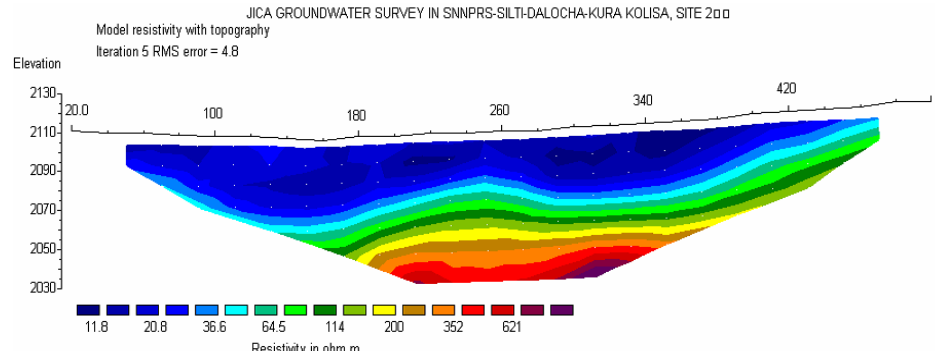


Figure 118-02 Silti - Dalocha - Kura Kolisa - Site 2

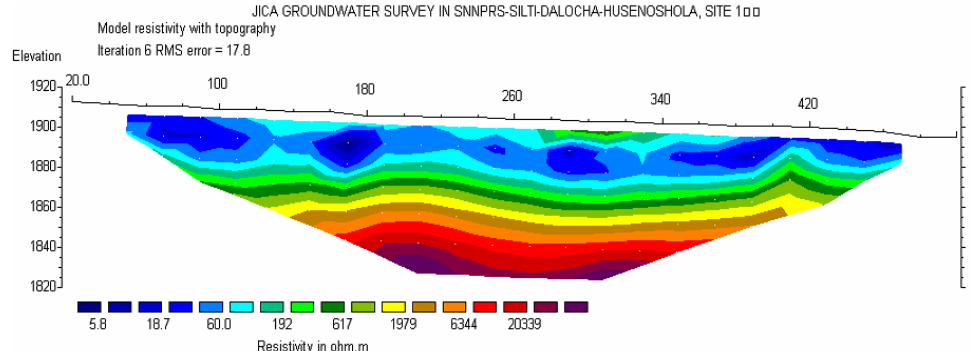


Figure 120-01 Silti - Dalocha - Husend Shola - Site 1

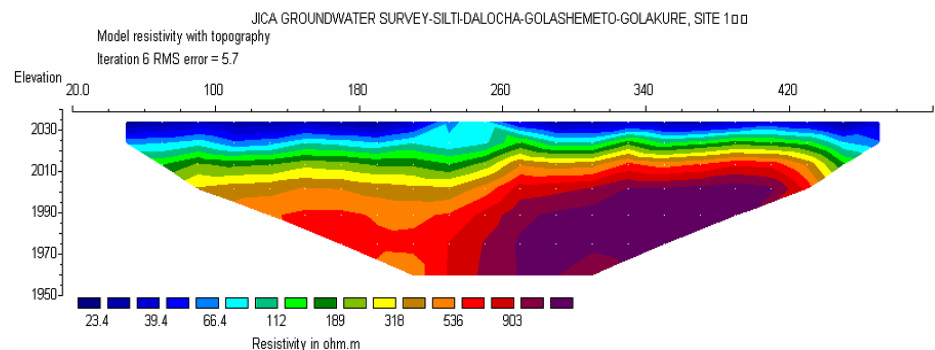


Figure 119-01 Silti - Dalocha - Golana Shemeto - Golakure

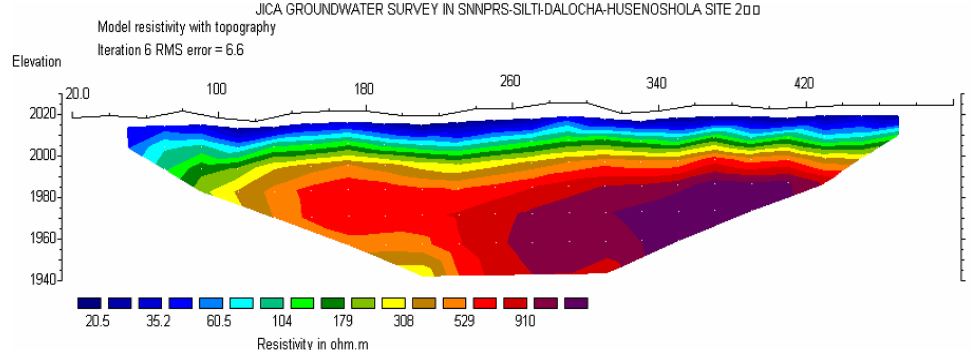


Figure 120-02 Silti - Dalocha - Husend Shola - Site 2

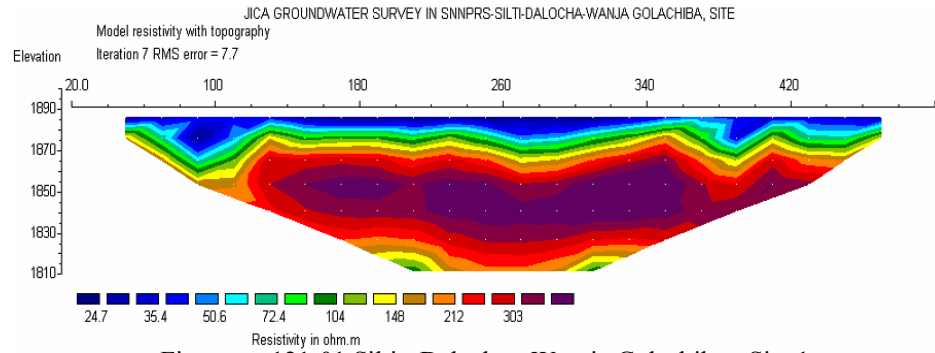


Figure 121-01 Silti - Dalocha - Waneja Golachiba - Site 1

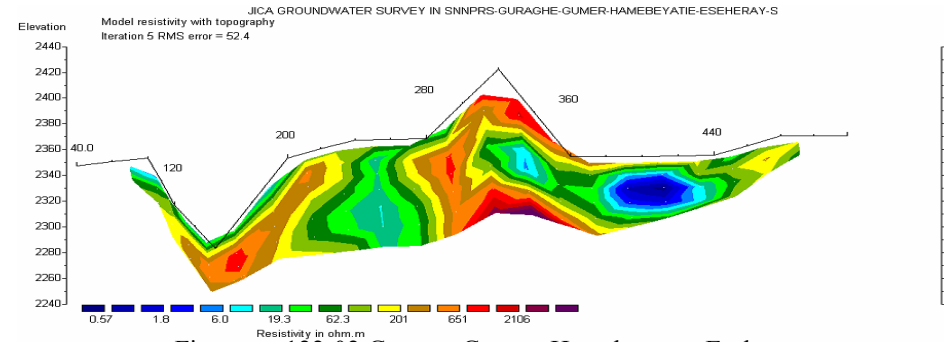


Figure 122-02 Gurage- Gumer- Hamebeyata - Escheray

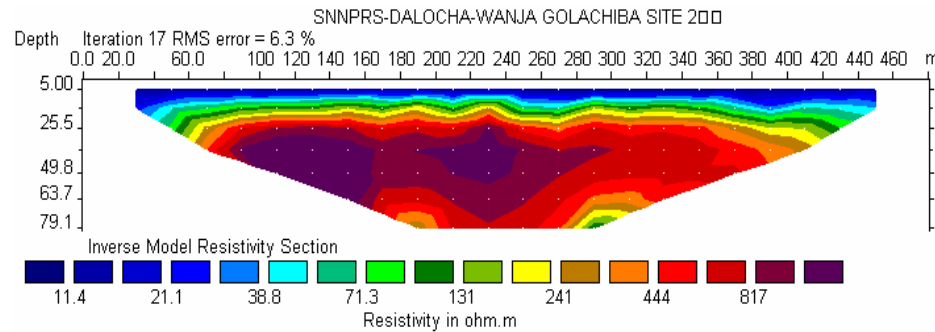


Figure 121-02 Silti - Dalocha - Waneja Golachiba - Site 2

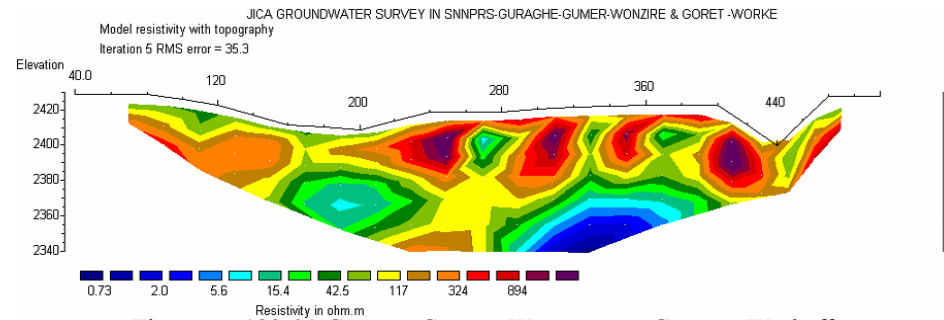


Figure 123-01 Gurage- Gumer- Wenwzerana Gorate - Workeffa

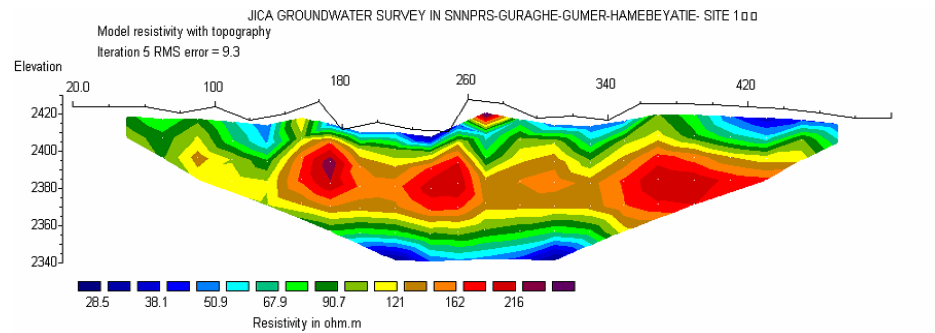


Figure 122-01 Gurage- Gumer- Hamebeyata - Site 1

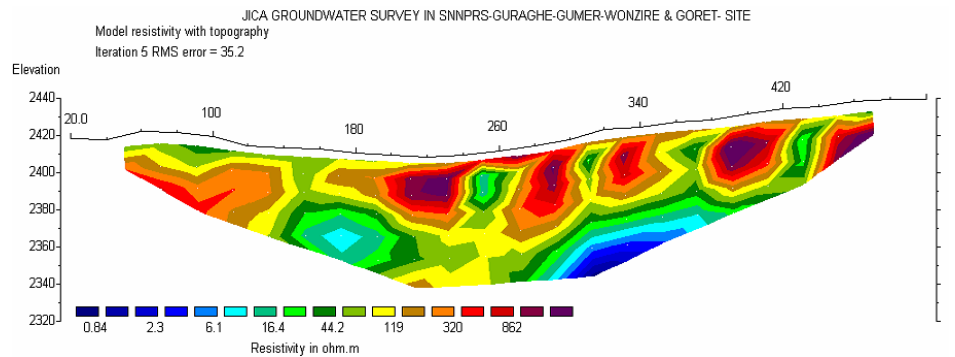


Figure 123-02 Gurage- Gumer- Wenwzerana Gorate - Site 2

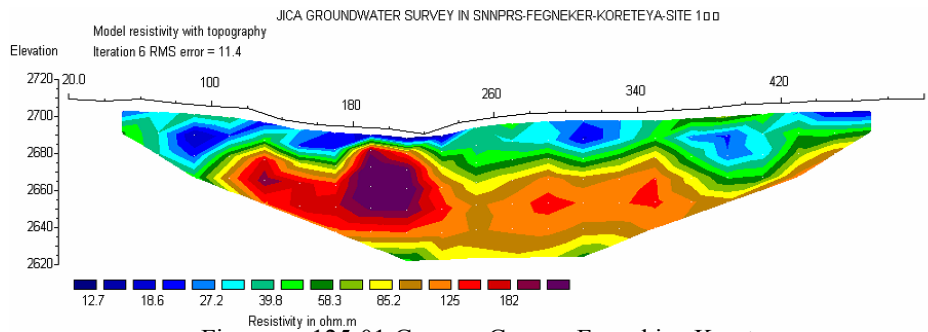


Figure 125-01 Gurage- Gumer- Fegnekir - Koreteya

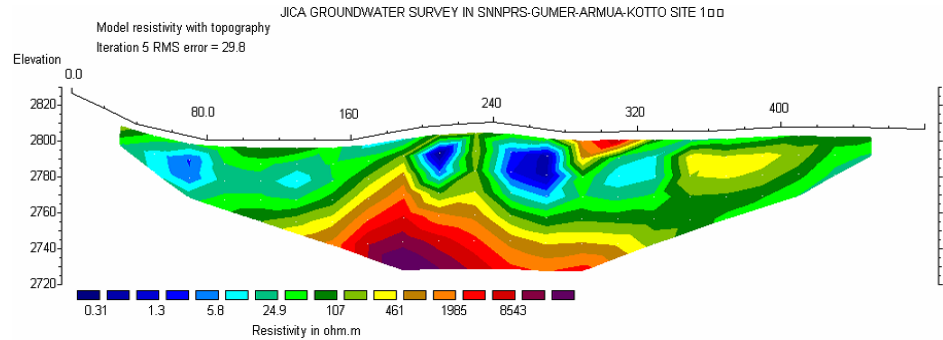


Figure 126-01 Gurage- Gumer- Aremua - Kotto

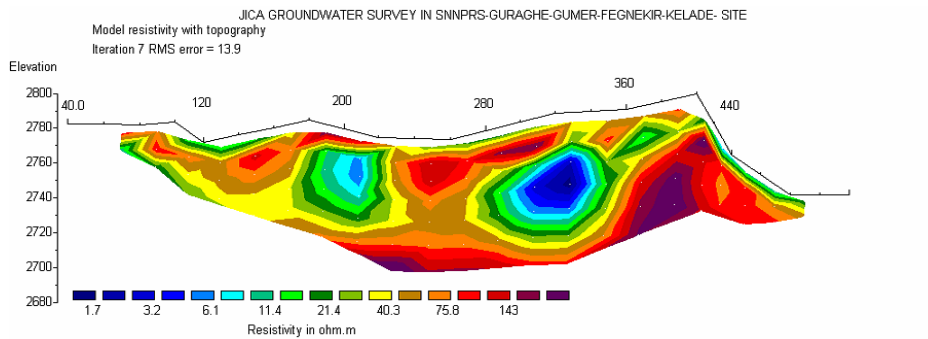


Figure 125-02 Gurage- Gumer- Fegnekir - Kelade

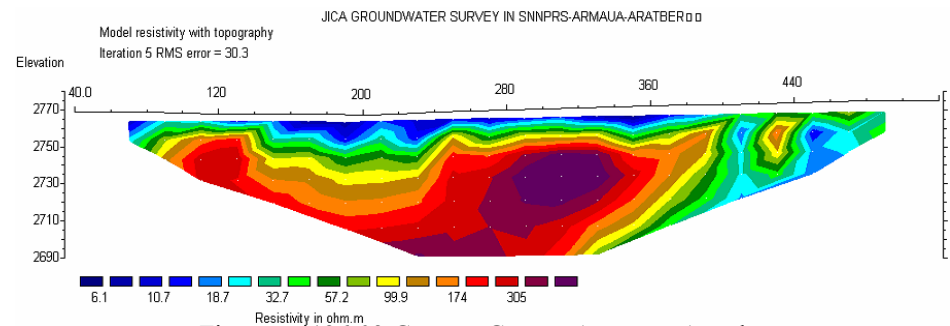


Figure 126-02 Gurage- Gumer- Aremua - Arateber

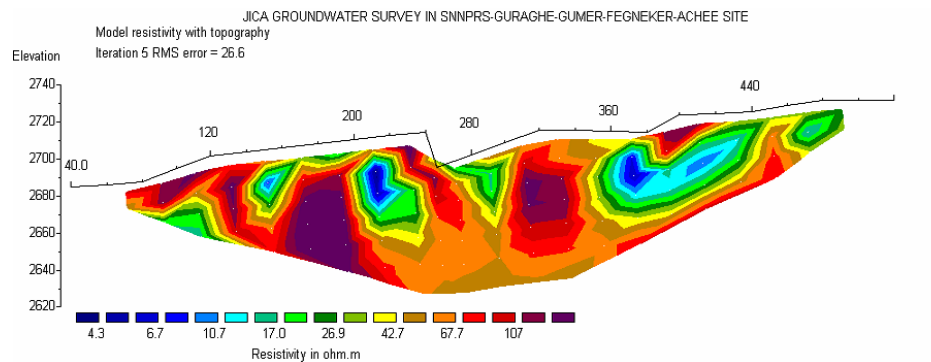


Figure 125-03 Gurage- Gumer- Fegnekir - Achee

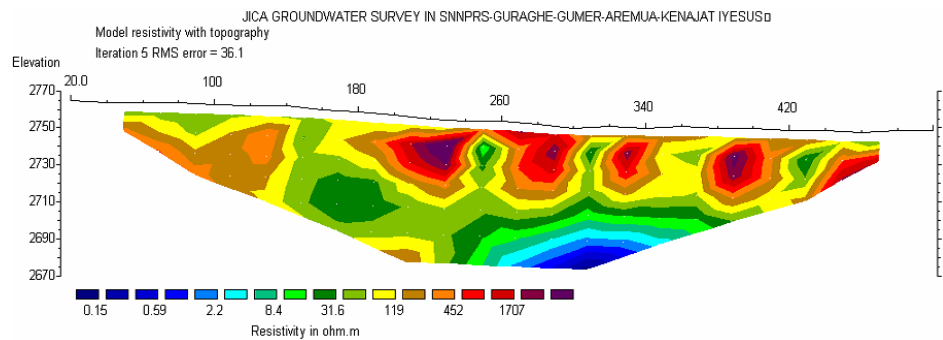


Figure 126-03 Gurage- Gumer- Aremua - Kenajat Iyesus

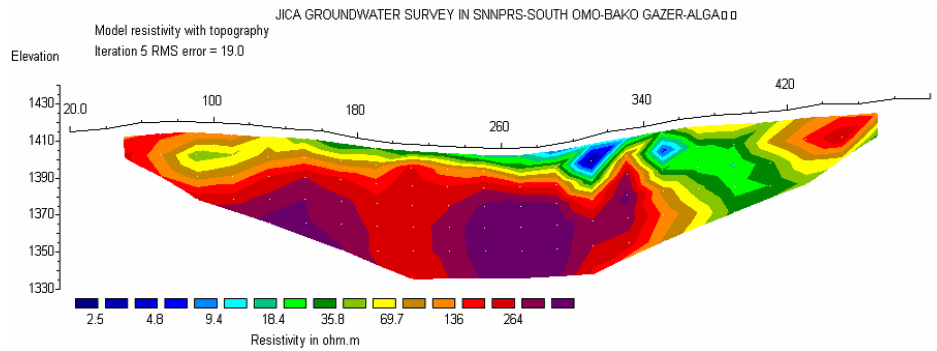


Figure 127 South Omo - Backo Gazer- Alga - Hulatenga Meda

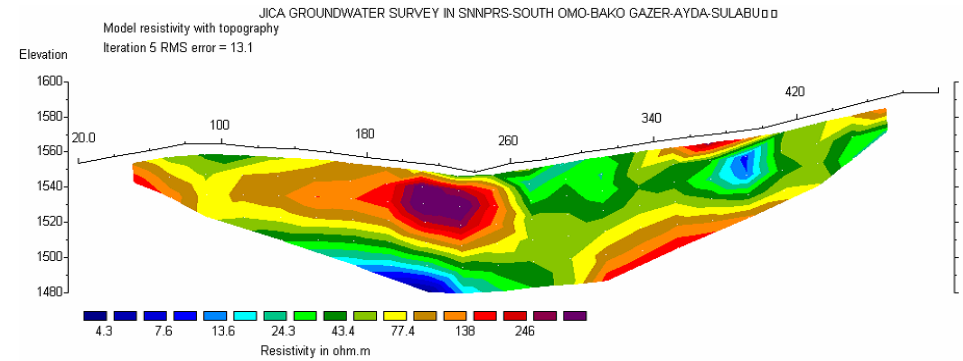


Figure 130-01 South Omo - Backo Gazer- Ayda - Sulabu

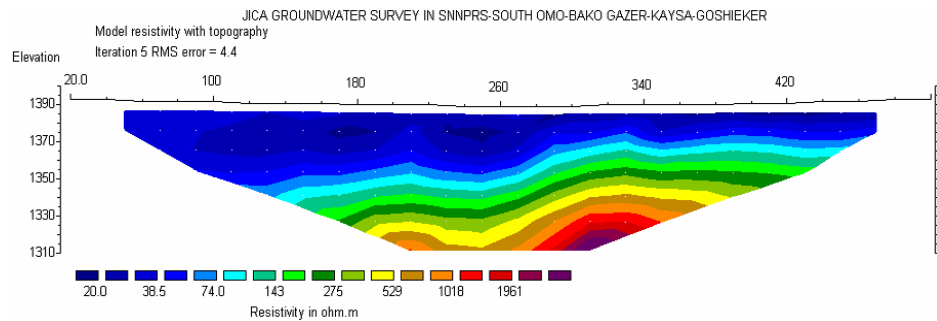


Figure 128-01 South Omo - Backo Gazer- Kaysa - Goshler

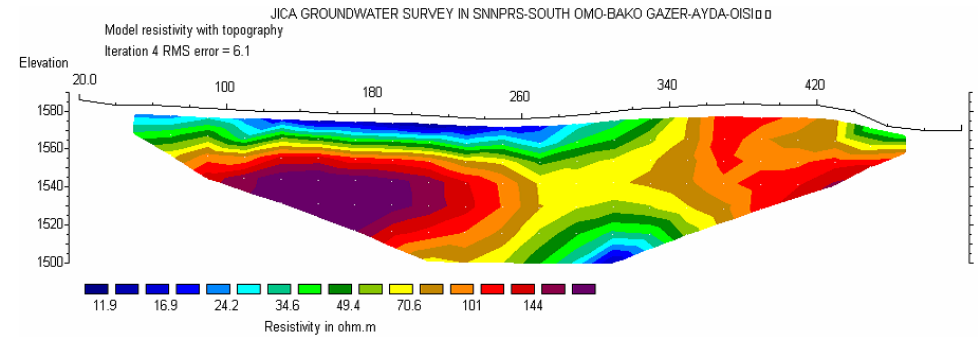


Figure 130-02 South Omo - Backo Gazer- Ayda - Oishi

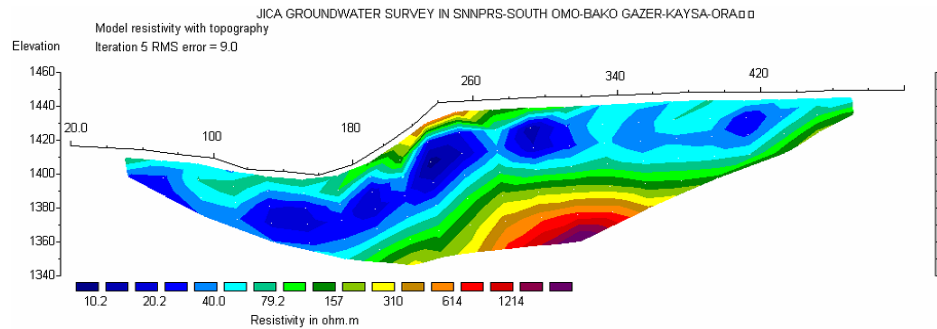
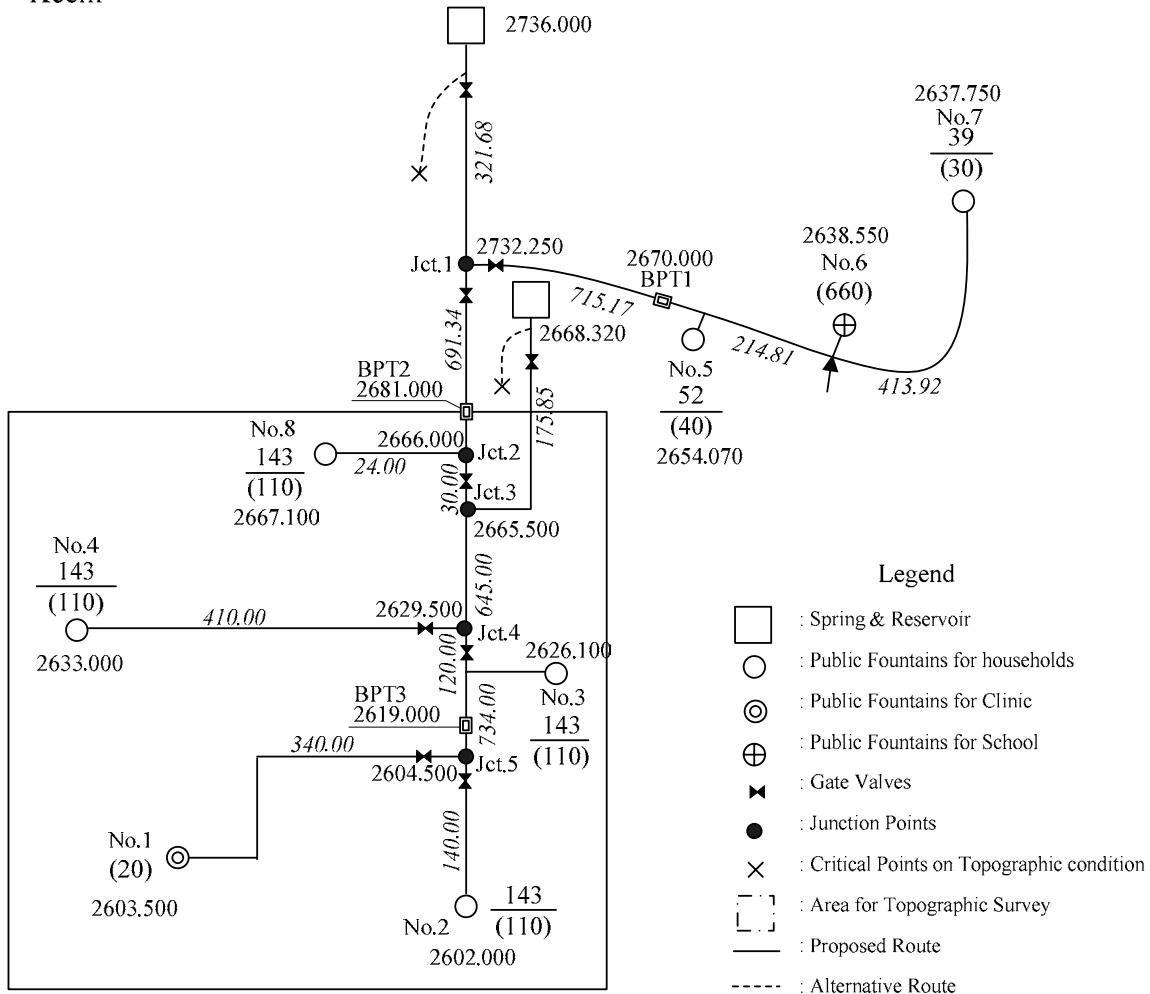


Figure 128-02 South Omo - Backo Gazer- Kaysa - Ora

**5.6**

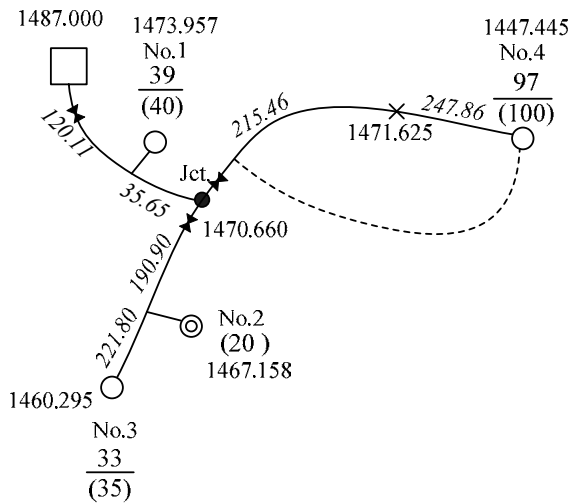
***Route Map of Target Communities (Spring)***

Kechi



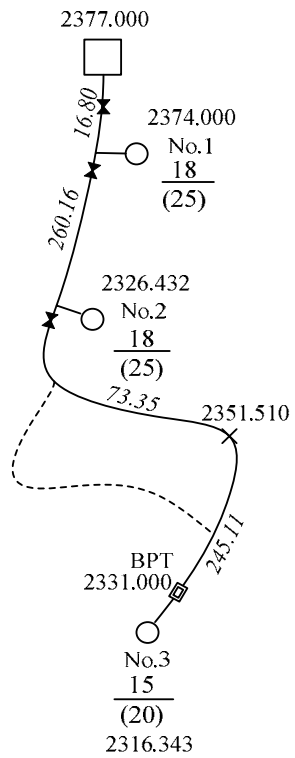
- Legend**
- : Spring & Reservoir
  - : Public Fountains for households
  - ⊙ : Public Fountains for Clinic
  - ⊕ : Public Fountains for School
  - : Gate Valves
  - : Junction Points
  - : Critical Points on Topographic condition
  - : Area for Topographic Survey
  - : Proposed Route
  - : Alternative Route
- $\frac{35}{(30)}$  for  : Number of Households, Above: 2014  
Below: 2004
- (660) for ⊕ : Number of Students
- (20) for ⊙ : Number of Visitors to Medical Clinic
- $\frac{340.00}{}$  : Pipe Distance
- 1471.625 : Ground Elevation

Waruma Kessa



**Selected Route Map (Kechi and Waruma Kessa)**

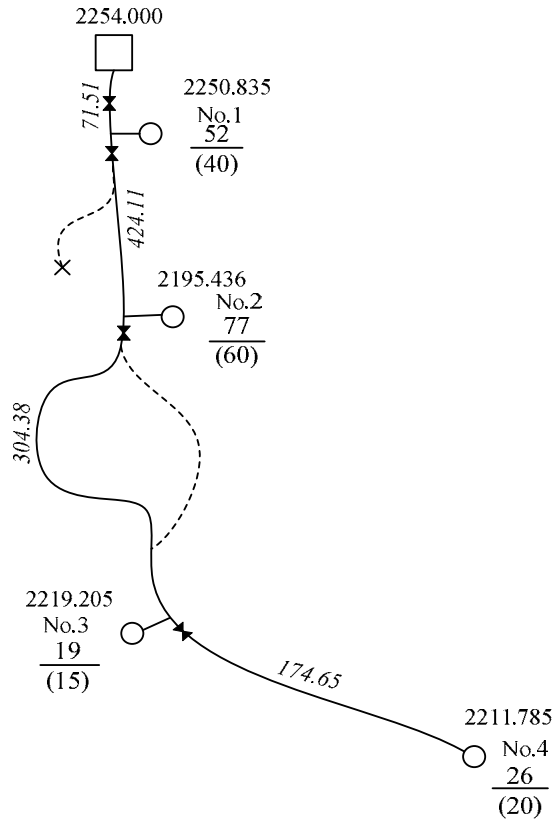
# Arusi Bale



## Legend

- : Spring & Reservoir
- : Public Fountains for households
- : Public Fountains for Clinic
- : Public Fountains for School
- : Gate Valves
- : Junction Points
- : Critical Points on Topographic condition
- : Area for Topographic Survey
- : Proposed Route
- : Alternative Route
- $\frac{35}{(30)}$  for : Number of Households, Above: 2014  
Below: 2004
- (660) for : Number of Students
- (20) for : Number of Visitors to Medical Clinic
- 340.00 : Pipe Distance
- 1471.625 : Ground Elevation

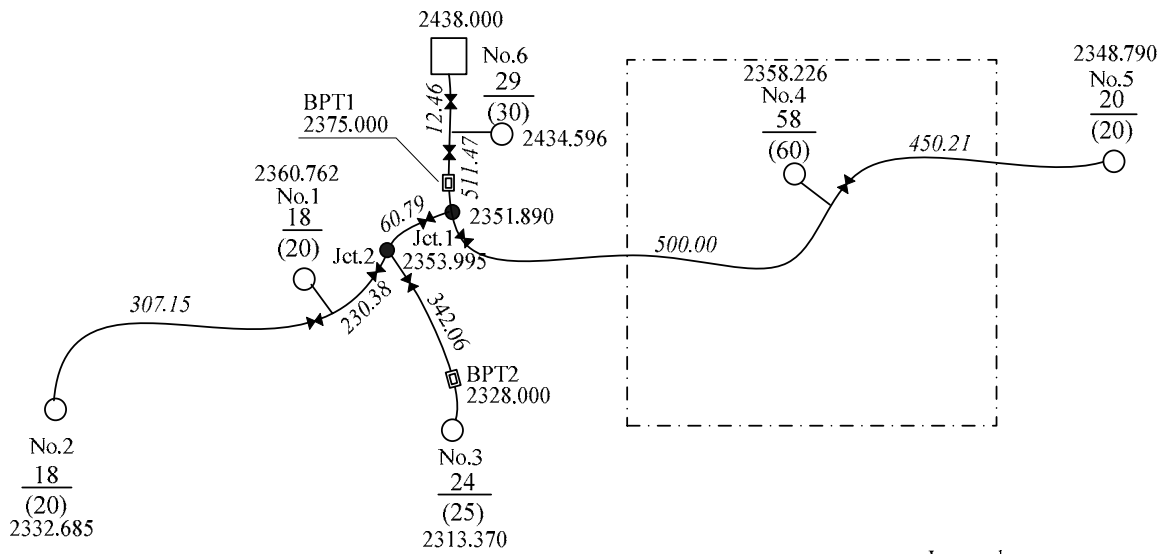
# Arusi Bale (Billille)



**Selected Route Map (Arusi Bale)**



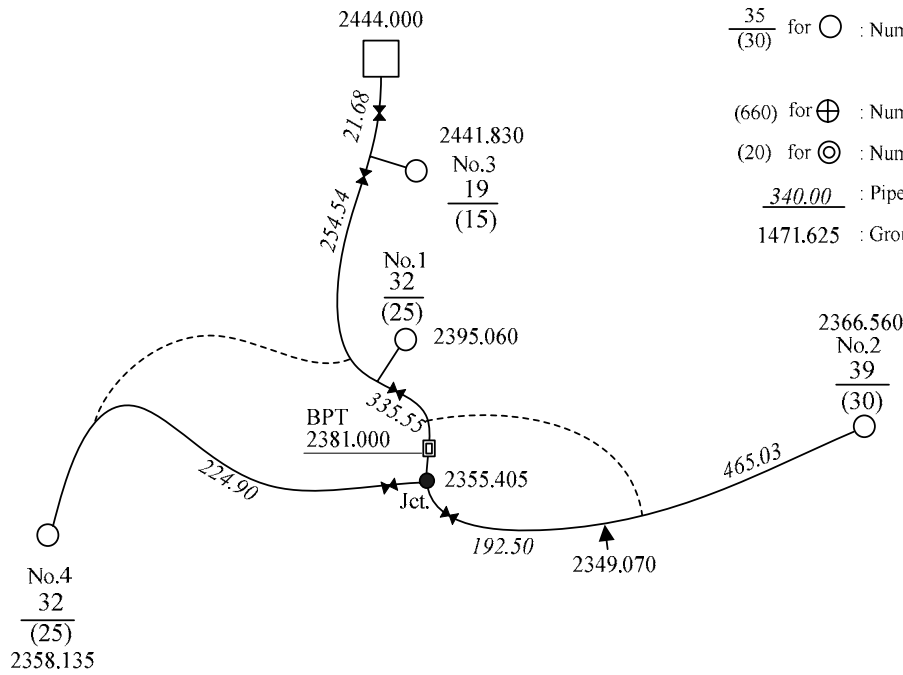
### Gudumu (Soso)



### Legend

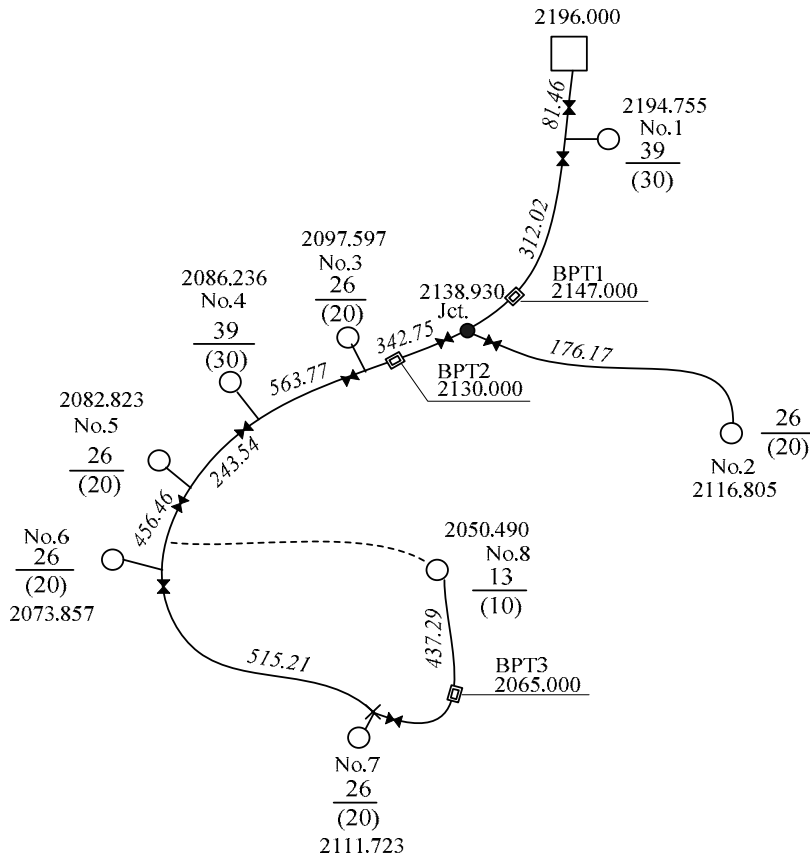
- : Spring & Reservoir
- : Public Fountains for households
- : Public Fountains for Clinic
- : Public Fountains for School
- : Gate Valves
- : Junction Points
- : Critical Points on Topographic condition
- : Area for Topographic Survey
- : Proposed Route
- : Alternative Route
- $\frac{35}{(30)}$  for : Number of Households, Above: 2014  
Below: 2004
- (660) for : Number of Students
- (20) for : Number of Visitors to Medical Clinic
- $\frac{340.00}{}$  : Pipe Distance
- 1471.625 : Ground Elevation

### Gudumu (Urgmo)



### Selected Route Map (Gudumu)

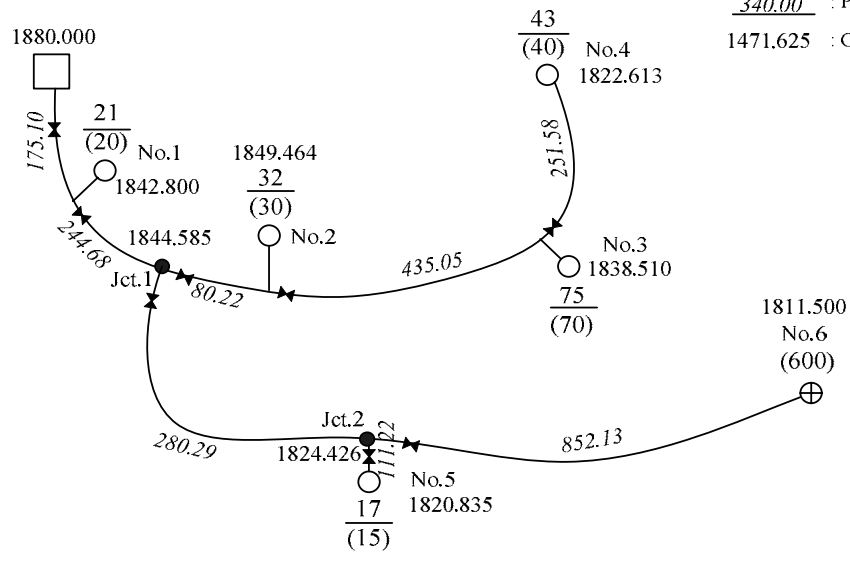
### Ofa (Yoge)



### Legend

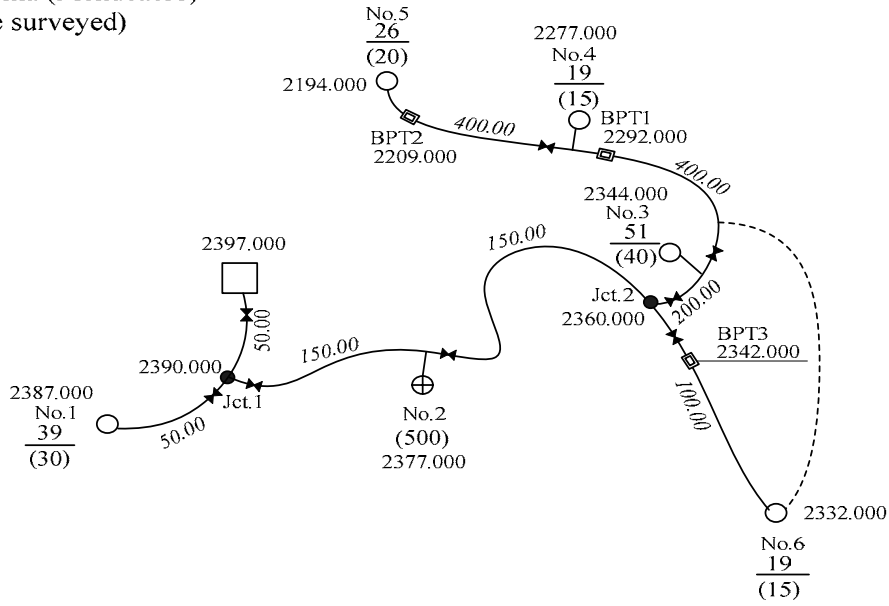
- : Spring & Reservoir
- : Public Fountains for households
- : Public Fountains for Clinic
- : Public Fountains for School
- : Gate Valves
- : Junction Points
- : Critical Points on Topographic condition
- : Area for Topographic Survey
- : Proposed Route
- : Alternative Route
- $\frac{35}{(30)}$  for : Number of Households, Above: 2014  
Below: 2004
- (660) for : Number of Students
- (20) for : Number of Visitors to Medical Clinic
- $\frac{340.00}{1471.625}$  : Pipe Distance  
Ground Elevation

### Sengeti

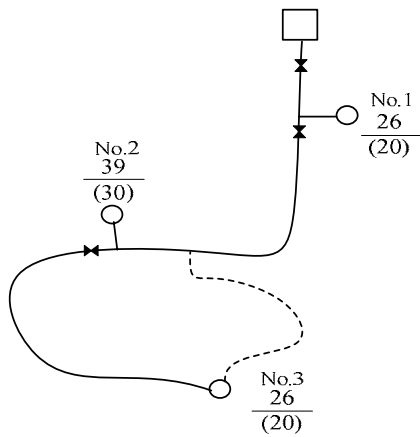


**Selected Route Map (Ofa and Sengeti)**

Ades Altema (Mendeaero)  
(Not to be surveyed)



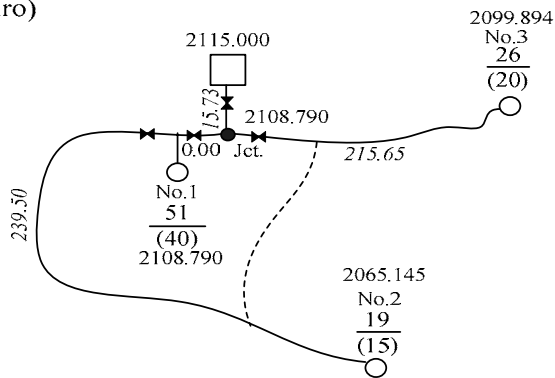
L/Arguba (Kora)



Legend

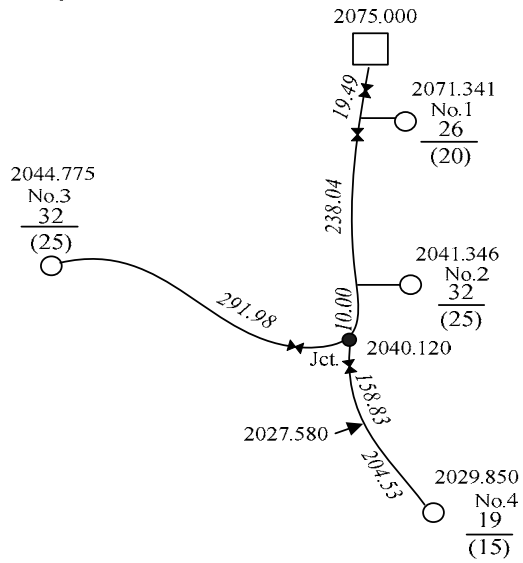
- : Spring & Reservoir
- : Public Fountains for households
- : Public Fountains for Clinic
- : Public Fountains for School
- : Gate Valves
- : Junction Points
- : Critical Points on Topographic condition
- : Area for Topographic Survey
- : Proposed Route
- : Alternative Route
- $\frac{35}{(30)}$  for : Number of Households, Above: 2014  
Below: 2004
- (660) for : Number of Students
- (20) for : Number of Visitors to Medical Clinic
- 340.00 : Pipe Distance
- 1471.625 : Ground Elevation

L/Arguba (Hamro)



Selected Route Map (Ades Altema and L/Arugba)

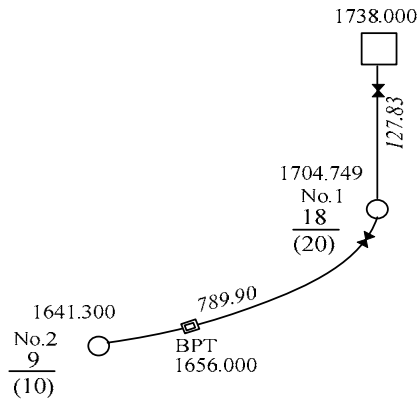
L/Arguba (Abello)



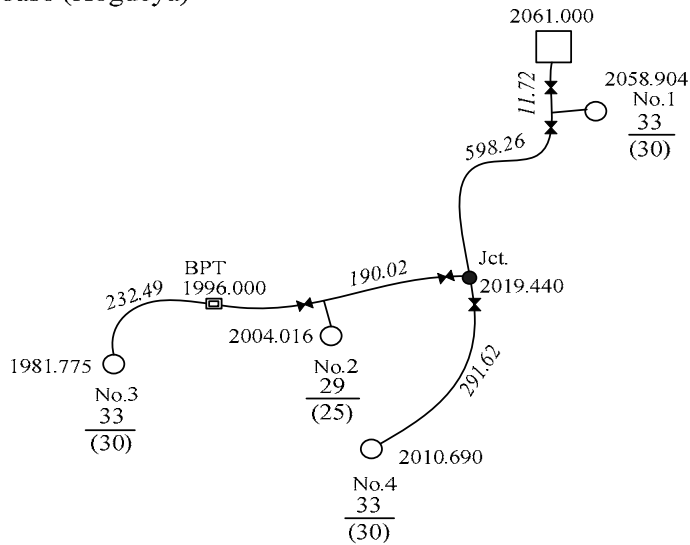
Legend

- : Spring & Reservoir
- : Public Fountains for households
- : Public Fountains for Clinic
- : Public Fountains for School
- : Gate Valves
- : Junction Points
- : Critical Points on Topographic condition
- : Area for Topographic Survey
- : Proposed Route
- : Alternative Route
- $\frac{35}{(30)}$  for : Number of Households, Above: 2014  
Below: 2004
- (660) for : Number of Students
- (20) for : Number of Visitors to Medical Clinic
- $\frac{340.00}{}$  : Pipe Distance
- 1471.625 : Ground Elevation

Walayte (Elcola)



Busabaso (Kogdeya)



Selected Route Map (L/Arugba, Walayte and Busabaso)

**5.7**

***Results of Groundwater Potential Assessment***













## The Results of Groundwater Potential Assessment(6/6)

No. in the original list	Scheme #.	Zone	Woreda	Kebele	Village name	Geology	Drilling method	Bases of groundwater development potential and well ability		Groundwater development potential	Depth of Aquifer		Static Water Level	Yield	Draw down	Depth of pump	Depth below pump	Drilling depth	East			North								
								Hydrogeological survey	2D-Electric sounding		Top	Bottom							GL-m	l/s	m	GL-m	m	GL-m	D	M	S	D	M	S
	122-2				Escheray	Tuff	Mud	○	○	poor	35.0	80.0	40.0	0.2	12.5	57.5	10.0	67.5	37	54	18	8	0	19						
	122-3				Site 3	Tuff	Mud	○	○	poor	35.0	80.0	40.0	0.2	12.5	57.5	10.0	67.5	37	54	6	7	59	7.9						
123	123-1	Gurage	Gumer	Wenwzerana Gorate	Workeffa	Tuff	Mud	○	○	fair	50.0	80.0	50.0	0.2	5.0	60.0	10.0	70.0	37	55	13	7	59	33						
	123-2			{Wonzire & Goret}	Site 2	Tuff	Mud	○	○	fair	50.0	70.0	50.0	0.2	5.0	60.0	10.0	70.0	37	55	8	7	59	43						
	123-3				Site 3	Tuff	Mud	○	○	poor	50.0	70.0	50.0	0.2	5.0	60.0	10.0	70.0	37	55	13	7	59	33						
124	124-1	Gurage	Gumer	Zara	Site 1	Ignimbrite, tuff	DTH	○	○	poor	35.0	70.0	35.0	0.2	5.0	45.0	10.0	55.0	37	56	16	8	0	24						
	124-2				Site 2	Ignimbrite, tuff	DTH	○	○	poor	35.0	70.0	35.0	0.2	5.0	45.0	10.0	55.0	37	56	49	8	0	28						
	124-3				Site 3	Tuff	Mud	○	○	poor	35.0	70.0	35.0	0.2	5.0	45.0	10.0	55.0	37	55	33	8	0	36						
125	125-1	Gurage	Gumer	Fegnekir	Koreteya	Tuff	Mud	○	○	fair	35.0	75.0	40.0	0.2	7.5	52.5	10.0	62.5	37	58	32	7	58	33						
	125-2				Kelade	Tuff	Mud	○	○	good	35.0	75.0	35.0	0.2	5.0	45.0	10.0	55.0	37	57	50	7	57	20						
	125-3				Achee	Tuff	Mud	○	○	good	35.0	75.0	35.0	0.2	5.0	45.0	10.0	55.0	37	58	40	7	58	33						
126	126-1	Gurage	Gumer	Aremua	Kotto	Tuff	Mud	○	○	poor	35.0	50.0	35.0	0.2	5.0	45.0	10.0	55.0	38	0	48	7	56	48						
	126-2				Arateber	Tuff	Mud	○	○	poor	55.0	75.0	55.0	0.2	5.0	65.0	10.0	75.0	38	0	15	7	57	32						
	126-3				Kenajat Iyesus	Tuff	Mud	○	○	fair	40.0	75.0	40.0	0.2	7.5	52.5	10.0	62.5	37	59	41	7	58	15						
		<b>Gurage</b>	<b>Gumer</b>	<b>Subtotal</b>			<b>15</b>											<b>950.0</b>												
127	127	South Omo	Backo Gazer	<u>Avnalem -&gt; Alga</u>	<u>Hulatenga Meda</u>	Granite	DTH	○	○	poor	35.0	60.0	40.0	0.2	5.0	50.0	10.0	60.0	36	33	1	5	47	1						
128	128-1	South Omo	Backo Gazer	<u>Tanbale -&gt; Kavsa</u>	<u>Goshler</u>	Basalt	DTH	○	○	fair	35.0	55.0	35.0	0.2	5.0	45.0	10.0	55.0	36	37	48	5	42	32						
	128-2				<u>Ora</u>	Basalt	DTH	○	○	good	35.0	80.0	35.0	0.2	5.0	45.0	10.0	55.0	36	37	2	5	44	10						
129	129-1	South Omo	Backo Gazer	<u>Avdamr -&gt; Muti</u>	<u>Wolsher</u>	Basalt	DTH	○	○	poor	35.0	70.0	35.0	0.2	5.0	45.0	10.0	55.0	36	32	11	5	56	12						
	129-2				<u>Zaddo</u>	Basalt	DTH	○	○	poor	35.0	70.0	35.0	0.2	5.0	45.0	10.0	55.0	36	32	25	5	56	20						
130	130-1	South Omo	Backo Gazer	<u>Aldemer -&gt; Ayda</u>	<u>Sulabu</u>	Basalt	DTH	○	○	good	35.0	70.0	35.0	0.2	5.0	45.0	10.0	55.0	36	34	0	5	54	37						
	130-2				<u>Oishi</u>	Basalt	DTH	○	○	good	35.0	75.0	35.0	0.2	5.0	45.0	10.0	55.0	36	34	9	5	54	50						
131	131	South Omo	Backo Gazer	<u>Lofit -&gt; Gazer</u>	<u>Goldat</u>	Basalt	DTH	○	○	poor	35.0	75.0	35.0	0.2	5.0	45.0	10.0	55.0	36	34	40	5	53	36						
		<b>South Omo</b>	<b>Backo Gazer</b>	<b>Subtotal</b>			<b>8</b>											<b>445.0</b>												
		<b>Total</b>					<b>214</b>	<b>214</b>	<b>167</b>									<b>12846.0</b>												

DTH:150, Mud:64

## **5.8**

# ***Pump Type Selection***

## Pump Types Adopted, Adopting Rate of Pumps

### 【Pump Types】

The Project will, from a view point of construction of shallow wells with hand pumps, adopt the following two types of hand pumps:

- Afri-dev with a maximum pumping head of 40 m
- Afri-deep with a maximum pumping head of 60 m

For cost estimation purposes, the adopting rate of the above pumps was determined from the following analysis.

### 【Examination】

Information used: records of drilling conducted by UNICEF in the target area

Selection of data: The following data were excluded from the analysis

- Dry wells
- Wells deeper than 80 m or shallower than 20m

A frequency distribution of data regarding one hundred twenty two (122) wells conforming to the above conditions was used for the analysis.

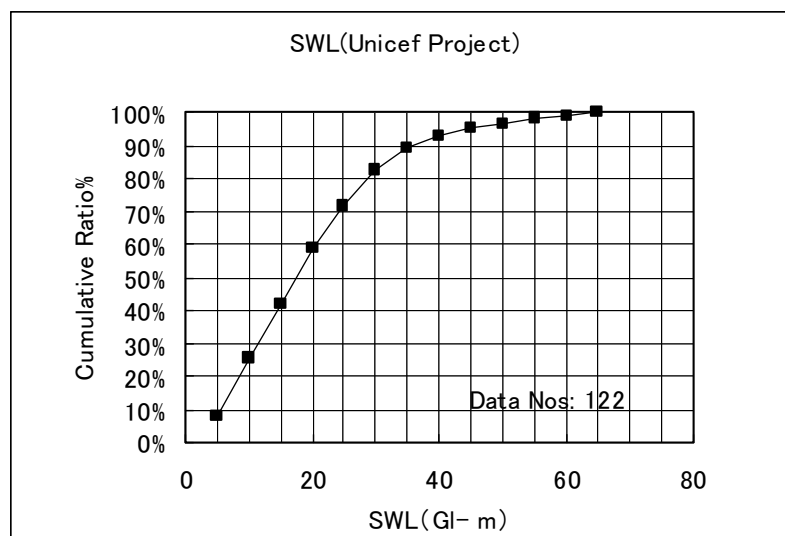
In addition, the following drawdowns were considered.

- Drawdown by pumping: 5 m
- Natural drawdown in dry season: 10 m

### 【Ratio of Pump Type to be adopted】

The following results were obtained.

SWL in record	SWL in dry season	DWL in dry season	Pump type	Rate
Deeper than 20 m	Deeper than 30 m	Deeper than 35 m	Afri-deep	40 %
Shallower than 20m	Shallower than 30 m	Shallower than 35 m	Afri-dev	60 %



**5.9**

***Database of Existing UNICEF Borehole***

### Database of Existing UNICEF Borehole

No.	Site name	Wereda	Zone	Easting	Northing	Altitude (m)	Source statuses	Constr.compl. Date	Donor Name	Depth(mt)	SWL (m.b.g.l)	Source yiled (l/s)	Pump cat.	Pump. Postion (m)	Caing type	Casing Diam.
1	Well No 1	Bena Tsemay	South Omo	37257547	592926		SHW	2002/9/4	UNICEF	40					PVC	
2	Well No 2	Hammer	"	37207901	555392		SHW	18/04/02	UNICEF	40	13.5	0.8	Afridev	38	PVC	4"
3	Well No 3	Hammer	"	37207026	554761		SHW	20/07/02	"	30	7.5	1	Afridev	29	PVC	4"
4	Well No 4	Bena Tsemay	"				SHW	27/04/02	"	33	15	1	Afridev	30	PVC	4"
5	Well No 5	Bena Tsemay	"				SHW	29/04/02	"	33.5	8	1.5	Afridev	30	PVC	4"
6	Well No 6	Hammer	"	362304	43539		SHW	2002/1/1/6	"	30	4.5	3	Afridev	25	PVC	4 1/2"
7	Doria 2,W.No. 8	Hammer	"	37228105	5212000		SHW	14/06/02	"	30	6	2.5	Afridev	25	PVC	4 1/2"
8	Doria 1,W.No. 7	Hammer	"	228175	521085		SHW	13/06/02	"	39	4.8	3			PVC	
9	Well No 9	Hammer	"	37229797	523707		SHW	19/06/02	"	27	7	0.8	Afridev	25	PVC	4 1/2"
10	Well No 10	Hammer	South Omo	37231490	543963		SHW	27/06/02	"	26.5	13.5	1	Afridev	26	PVC	4 1/2"
11	Tima Gurda W.No 11	Hammer	"	3722301	557036		SHW	2002/5/7	"	51	28	1.5	Afridev	45	PVC	4 1/2"
12	Well No 12	Hammer	"	37218539	55397		SHW	2002/10/7	"	53	25	1.5	Afridev	45	PVC	4"
13	Well No 13	Hammer	"	37219235	554469		SHW	2002/12/7	"	51	28	1	Afridev	43	PVC	4"
14	Silarga Well No. 14	Hammer	"	37219616	557715		SHW	17/07/02	"	41	27	1	Afridev	40	PVC	4"
15	Tinishu Boria W.No15	Hammer	South Omo	37220547	557491		SHW	21/07/02	"	38.2	24	1.5	Afridev	34	PVC	4"
16	Bela W.No 16	Hammer	"				SHW	27/07/02	"	11					PVC	
17	Lebela W.No 17	Hammer	"	3722527	54826		SHW	30/07/02	"	27	4	2	Afridev	24	PVC	4"
18	Arna W.No. 18	Hammer	"				SHW	2002/2/8	"	25.5	14	1.5	Afridev	24	PVC	4"
19	Near the clinic W.No. 19	Salamago	"	37183142	688162		SHW	13/08/02	"	21	5	1.5	Afridev	20	PVC	4"
20	Near police st. W.No.20	Salamago	"	3718260	688088		SHW	15/08/02	"	64		0.1			PVC	
21	Near Hana river W.No 21	Salamago	"	37183069	687813		SHW	17/08/02	"	27	26	0.1			PVC	
22	At the back of Hostel school W.No. 22	Salamago	"	37183235	688349		SHW	20/08/02	"	15.5	13.5	0.1			PVC	
23	Well No. 23	Salamago	"	37178650	689122		SHW	28/08/02	"	19					PVC	
24	Gerbiber	Siltie	Siltie				"	29/11/95 E.C	"	24	3.72		Afridev	21.4		4"
25	Megdel	Siltie	Siltie				"	1/12/95 E.C	"	31	16.3		Afridev	27.66		4"
26	Mahel Eyekocho	Siltie	Siltie				"	4/13/95 E.C	"	44			Afridev	37.02		4"
27	Kito	Siltie	Siltie				"	2/13/95 E.C	"	32	21.1		Afridev	28.65		4"
28	Sullan	Lanfuro	"				"	15/12/95 E.C	"	64	23.7		Afridev	56.55		4"
29	Gebaba	Lanfuro	"				"	20/12/95 E.C	"	60	22.6		Afridev	53.76		4"
30	Gebrias	Lanfuro	"				"	24/12/95 E.C	"	18	5		"	14.7		4"
31	Tache Mukera	Lanfuro	"				"	29/12/95 E.C	"	21	9.8		"	14.7		4"
32	Agam & Dengez	Lanfuro	"				"	25/12/95 E.C	"	40	9.4		"	31.44		4"
33	Titi & Chumbul	Lanfuro	"				"	26/12/95 E.C	"	38	19.25		"	28.65		4"
34	Meccy project	Meskan	Gurague				"	10/01/96 E.C	"	10			"	7.65		4"
35	Zemzem aecbi School	Sodo	Gurague				"	13/01/96 E.C	"	36			"	28.65		4"
36	Labo	Soro	Hadiya				"		"	73	63	0.3			PVC	4"
37	Kolle	Lemo	Hadiya				"		"	49	23.7	1.5 2			PVC	4"
38	Adsholara	Soro	Hadiya				"		"	58	38.3	2			"	4"
39	Stna	Lemo	Hadiya				"	25/8/03	"	72.8					"	4"
40	Mehal tomko	Lemo	Hadiya				"	28/8/03	"	55	22.4	0.5 1			"	4"
41	Mehal tomko	Lemo	Hadiya				"	2003/2/9	"	76	40.6	0.5			"	4"
42	Tuka	Lemo	Hadiya				"	2003/6/9	"	42	10	2			"	4"
43	Masamo	Lemo	"				"	Oct.14/03	"	78.7	64	1 1.5			"	4"
44	Eoldere	Lemo	"				"		"	37	17.6	2 2.5			"	4"
45	Lan Tuka	"	"				"	2003/5/9	"	89					"	4"
46	Teaheer's Residence (Gonto)	Alminch Zuria	Gamo Goffa				"	30/09/95 E.C	"	34	8.4	1.5	Afridev	27	PVC	4"
47	Gonto_chamo(W.No.3)	Alminch Zuria	Gamo Goffa				"	04/10/95E.C	"	16	6	0.3	Indian Mark II	12	PVC	
48	Dugo	Alminch Zuria	Gamo Goffa	32900	644730		"	07/10/95 E.C	"	18	2.6	2	Afridev	12	PVC	4"
49	Budin No 3	Mirabe Abya	Gamo Goffa	361711	71509		"	17/09/95 E.C	"	43	22.5	0.5	Indian Mark III	40	PVC	4"

### Database of Existing UNICEF Borehole

No.	Site name	Wereda	Zone	Easting	Northing	Altitude (m)	Source statuses	Constr.compl. Date	Donor Name	Depth(mt)	SWL (m.b.g.l)	Source yiled (l/s)	Pump cat.	Pump. Postion (m)	Caing type	Casing Diam.
50	Shaita	Mirabe Abya	Gamo Goffa	360843	712870		"	20/09/95 E.C	"	48	35	0.5	Indian Mark II	44	PVC	4"
51	Keme	Mirabe Abya	Gamo Goffa	361792	712543		"	24/09/95 E.C	"	52	29.7	0.6	Indian Mark II	46	PVC	4"
52	Ganta	Mirabe Abya	Gamo Goffa				"	11/10/95 E.C	"	8	1.6	2.5	Afridev	6	PVC	4"
53	Shaita	Mirabe Abya	Gamo Goffa	360843	712870		"	13/09/95 E.c	"	51	34.7				PVC	
54	Luda	Alminch Zuria	Gamo Goffa				"	02/10/95 E.C	"	15						
55	Done Bicha	Alminch Zuria	Gamo Goffa	328319	647943		"	14/10/95 E.C	"	6	1	1.2	Afridev	2.8	PVC	4"
56	Yochie	Alminch Zuria	Gamo Goffa				"	10/10/95 E.C	"	25	2.2	1	Afridev	18	PVC	4"
57	Ganjule (Mehal mela)	Alminch Zuria	Gamo Goffa	330935	649080		"	13/10/95 E.C	"	8	1.15		Afridev	5	PVC	4"
58	School _ compound (Gonto)	Alminch Zuria	Gamo Goffa	329097	643637		"	28/09/95 E.C	"	25	10.4	2	Afridev	18	PVC	4"
59	Mehal Bicha	Alminch Zuria	Gamo Goffa	328048	648741		"	14/10/95 E.C	"	16	2	3	Afridev	12	PVC	4"
60	Block 4	Deramalo	Gamo Goffa	307704	696723		"	16/11/95 E.C	"	24						
61	Block 7	Deramalo	Gamo Goffa	308416	69662		"	03/11/95 E.C	"	22						
62	Warueake	Deramalo	Gamo Goffa				"	10/11/95 E.C	"	22	2.8	5	Afridev	18	PVC	4"
63	Wamala	Deramalo	Gamo Goffa	309866	703517		"	19/11/95 E.C	"	13	6.7	0.3	Afridev	8	PVC	4"
64	Block - 1	Deramalo	Gamo Goffa	307450	696787		"	2/11/95 E.C	"	16	4	0.2		7.5	PVC	4"
65	Walacha	Deramalo	Gamo Goffa	311065	700164		"	10/11/95 E.C	"	25	11.1	0.5	Afridev	18	PVC	4"
66	Hafero	Wonago	Gedeo	381847	61922		"		"	73	30.5				PVC	5"
67	Sokiche	Wonago	Gedeo	381512	61548		"		"	52	17.4				PVC	4"
68	Sokiche	Wonago	Gedeo	381514	61532		"		"	59.5	28.6				PVC	5"
69	Kercha village	Wonago	Gedeo	381535	61938		"		"	52	19				PVC	5"
70	Fara Village	Wonago	Gedeo	381645	62007		"		"	72					PVC	5"
71	Saga	Bensa	Sidama	420760	715353		"	Apr.7/03	"	49	13	0.25	Afridev	36	PVC	4"
72	Hollo sole	Hulla	Sidama	353425	63452		"	Apr. 11/03	"	40	8		Afridev	32	PVC	4"
73	Hankudino (Budussa)	Bensa	Sidama	384941	62557		"	Apr. 8/03	"	52	24		Indian mark II	48	PVC	4"
74	Woma1	Boricha	Sidama	352404	65357		"	Apr. 19/03	"	64	40.7		Indian mark III	57	PVC	4"
75	Woma2	Boricha	Sidama	424541	764119		"	Apr.23/03	"							
76	Arro	Boricha	Sidama	470980	764085		"	May 1/03	"	61	56					
77	Unit 3 2 camp	Awassa	Sidama	431060	780015		"	May 3/03	"	37	19.7		Afridev	32	PVC	4"
78	Udo Gorfamo	Awassa	Sidama				"	May 8/03	"	58	34		Indian mark II	45	PVC	4"
79	Udo Bulancho	Awassa	Sidama				"	May 6/03	"	52	29		Indian mark II	42	PVC	4"
80	Gonowa	Awassa	Sidama				"	May 11/03	"	58	39			48	PVC	4"
81	Gurie jibito 1st	Aleta wondo	Sidama	430035	728438		"	Mar. 14/03	"	56	13.8		Indian mark II	39	PVC	5"
82	Bisadime shaba	Aleta wondo	Sidama	420635	732564		"	Mar. 21/03	"	95	70		Indian mark III	82	PVC	4"
83	Arjama	Aleta wondo	Sidama				"	Mar. 26/03	"	91	21		Indian mark III	75	PVC	4"
84	Gurie jibito 2nd	Aleta wondo	Sidama				"	Mar. 28/03	"	42.6	26	0.3 0.25	Indian mark II	39	PVC	5"
85	Adille debo	Sodo	Gurage	451127	900107		"	24/5/95	"	58	28.6	2			PVC	5"
86	Deteka area1	Sodo	Gurage	498705	896898		"	23/5/95	"	44	18.8	3			PVC	5"
87	Deteka area2	Sodo	Gurage				"	23/01/03	"	40.6	20	2			PVC	5"
88	Gogeti	Sodo	Gurage				"	28/5/95	"	48	20.3	3	Indian mark II	42	UPVC	127mm
89	Meraes # 2	Meskan	Gurage	442948	897069		"	1995/12/5	"	24.5	14				PVC	125mm
90	Hanas Gebiye	Meskan	Gurage	444749	998561		"	1995/8/5	"	14.8	4	>10			PVC	125mm
91	Meymen sefer	Meskan	Gurage	444332	899113		"	1995/9/5	"	43	8	>5			PVC	125mm
92	Mender # 2(1)	Meskan	Gurage	442065	891503		"	1995/9/4	"	28	14.2	3			PVC	100mm
93	Mender # 2(2)	Meskan	Gurage	444035	591782		"	1995/10/4	"	35	14.6	3			PVC	100mm
94	Buta seter1	Meskan	Gurage	444974	391416		"	14/04/95	"	37	13.8	3			PVC	125mm
95	Bease sefer2	Meskan	Gurage	444437	890548		"	1992/12/4	"	34	14.3	3			PVC	125mm
96	Shabo sefer1	Meskan	Gurage	441990	892195		"		"	40	17	3			PVC	125mm
97	Shabo seter2	Meskan	Gurage	445017	889303		"	17/4/95	"	40	17.6	3			PVC	125mm
98	Shabo sefer3	Meskan	Gurage	445764	889614		"	18/4/95	"	40	17.6	3			PVC	125mm
99	Didahalibe W.No. 2	Mareko	Gurage				"	31/12/02	"	40.6	8	3.5			PVC	
100	Dida Halibo W. No 1	Mareko	Gurage				"	30/12/02	"	41.6	18	2			PVC	5"

A5.9.2



### Database of Existing UNICEF Borehole

No.	Site name	Wereda	Zone	Easting	Northing	Altitude (m)	Source statuses	Constr.compl. Date	Donor Name	Depth(mt)	SWL (m.b.g.l)	Source yiled (l/s)	Pump cat.	Pump. Postion (m)	Caing type	Casing Diam.
101	Waja Jane Damera W.No1	Mareko	Gurage	-	-		"	2003/2/1	"	35.6	13.35	2.5	-	-	PVC	5"
102	Damera W.No 2	Mareko	Gurage	-	-		"	2003/3/1	"	37.6	13.85	3	-	-	PVC	5"
103	Wanze Akalaloi	Mareko	Gurage	-	-		"	14/01/03	"	45.1	20.25	3.5	-	-	PVC	5"
104	Hollo sole	Mareko	Gurage	-	-		'	24/01/03	'	36.6	10.25	2.5	-	-	PVC	5"
105	Hankudino (Budussa)	Mareko	Gurage	-	-		'	28/02/03	'	31.6	8.6	2	-	-	PVC	5"
106	Tekore	Kadida Gamela	KT				'		'	40	17	2.5	Afridev	27	PVC	4"
107	Futura	Kadida Gamela	KT							30	6	3	Afridev	27	PVC	4"
108	Deneka	Kadida Gamela	KT							49.5	26	2.5	Afridev	27	PVC	4"
109	Wonko	Kadida Gamela	KT							32	1.5	3	Afridev	24	PVC	4"
110	Ambomsa	Kadida Gamela	KT							72	51	0.5				
111	Azedebo	Kadida Gamela	KT							42	6	3	Afridev	24	PVC	4"
112	Amercho	Angacha	KT							42	6	3	Afridev	27	PVC	4"
113	Bucha(Gubena	Angacha	KT							47.5	26	3	Afridev		PVC	4"
114	Geremba	Angacha	KT							49	17	2	Afridev		PVC	4"
115	Bucha(Aresha)	Angacha	KT							64	38	1				
116	Bonga	Angacha	KT							79	17	2.5	Afridev		PVC	4"
117	Seccoshol	Kindokosha	Wolayita	349771	768266	1999				54.8	39	0.3	Indian Mark II	51	PVC	4"
118	Doga Shecshoz	Kindokosha	Wolayita	352567	765615	2042				82	58	0.8	Indian Mark II	48	PVC	4"
119	Ueshamino	Kindokosha	Wolayita							74	47.6	1	Indian Mark II	48	PVC	4"
120	Guneno	Boloso Sora	Wolayita							70						
121	Shomba	Sodo Zuria	Wolayita							78	38	5	Indian Mark II	48	PVC	4"
122	Doga Shakes	Kindokosha	Wolayita	351041	766806	2021				82	42	1	Indian Mark II	61	PVC	4"
123	Guneno Ushamio	Boloso Sora	Wolayita							61	25	6	Indian Mark II	48	PVC	4"
124	Doge Shomeso Sch.	Kindokosha	Wolayita							82						
125	Kuto Serpela	Sodo Zuria	Wolayita							64	27	6	Indian Mark II	48	PVC	4"
126	Shamba	Sodo Zuria	Wolayita							62.5	38.4	2	Indian Mark II		PVC	4"
127	Shamba School	Sodo Zuria	Wolayita							62	38	2	Indian Mark II		PVC	4"
128	Sisota	Kochore	Gedeo	409680	664454	1718				78			Indian MarkII		PVC	4"
129	Sigiga1	Kochore	Gedeo	407764	663613	1835				42	25		Afridev		PVC	4"
130	Sigiga2	Kochore	Gedeo	406764	663405	1747				56	31.7		Afridev		PVC	4"
131	Anchebe	Kochore	Gedeo	408236	660558	1811				55	25.6		Afridev		PVC	4"
132	Biloya1	Kochore	Gedeo	406722	670682	1894				54	36.6		Afridev		PVC	4"
133	Biloya2	Kochore	Gedeo	406410	670326	1856				66	13.7		Afridev		PVC	4"
134	Karasoditi1	Wonago	Gedeo	413708	695853	1960				64	47.5		Indian Mark II		PVC	4"
135	Karasoditi2	Wonago	Gedeo	413468	696744	1927				57	31.7		Afridev		PVC	4"
136	Thokicha	Wonago	Gedeo	420351	697553	1673				64	43.9		Afridev		PVC	4"
137	Dila Gumbe1	Shebedino	Sidama	435862	756068	1804				52	18.2		Afridev		PVC	4"
138	Dila Gumbe2	Shebedino	Sidama	435856	757401	1818				64	28.9		Afridev		PVC	4"
139	Dila Gumbe3	Shebedino	Sidama	436407	758028	1808				52	21.3		Afridev		PVC	4"
140	Sedequa	Shebedino	Sidama	439416	756559	1841				40	21.3		Afridev		PVC	4"
141	Teremesa	Shebedino	Sidama	439939	757691	1849				55	15.8		Afridev		PVC	4"
142	Chelbesa1	Dale	Sidama	421200	740964	1607				34	6.4		Afridev		PVC	4"
143	Chelbesa2	Dale	Sidama	421443	743041	1612				34	7.6		Afridev		PVC	4"
144	Chelbesa3	Dale	Sidama	421256	742626	1619				28	6.4		Afridev		PVC	4"
145	Chelbesa4	Dale	Sidama	421096	741854	1613				34	13.7		Afridev		PVC	4"
146	Dessie	Dale	Sidama	423170	741213	1611				52			Afridev		PVC	4"
147	Wonenta	Dale	Sidama	429933	743188	1772				125	80				PVC	4"
148	Gelowacho1	Dara	Sidama	427522	713051	1937				45	18.6		Afidev		PVC	4"
149	Gelowacho2	Dara	Sidama	426694	713727	1937				100	61		Afidev		PVC	4"
150	Dibicha1	Aleta wondo	Sidama	423780	718812	1600				38	18.3		Afidev		PVC	4"
151	Dibicha2	Aleta wondo	Sidama	424134	718233	1608				54	30.8		Afidev		PVC	4"

**5.10**  
***Specification for Ethiopian Drinking Water  
Quality Guidelines***

THE FEDERAL DEMOCRATIC REPUBLIC OF **ETHIOPIA**  
MINISTRY OF WATER RESOURCES

**SPECIFICATION FOR  
ETHIOPIAN DRINKING WATER  
QUALITY GUIDELINES**

*September 2002  
Addis Ababa*

## **PREFACE**

The development of tailor made national water quality guideline is necessary to promote and protect the public health, prevent and control diseases as well as to address the water quality concerns of the country. This guideline is developed on the basis of latest publications of WHO Guidelines for Drinking Water Quality Volumes- 1, 2, 3 and Addendum of volume-1 and taking into consideration a variety of local factors such as geographical, socio-economic and environmental conditions.

It is believed that this guideline is used as Ethiopian Drinking Water Quality Guideline encompassing recommendations for water quality requirement that will be fit for human consumption and other domestic purposes as well as water quality monitoring.

This guideline is dynamic and has to be improved and updated with new findings and developments in the field. Therefore, constructive comments and suggestions are always welcome.

## 1.0 SCOPE

This tailor made guideline value, developed on the principles of risk-benefit approach or acceptable risk, represents the concentration of the constituents that does not result in any significant risk to the health of the consumer over the Ethiopian lifetime of consumption.

## 2.0 APPLICATION

This guideline applies to microbiological, physical, chemical, radiological quality of drinking water. It is relevant to all domestic water uses such as drinking, food preparation and personal hygiene.

## 3.0 REQUIREMENTS

The basic quality requirements for drinking water are illustrated as follows: -

- 3.1 The drinking water shall be free from any diseases causing pathogenic organisms and concentration of toxic chemical compounds that have adverse effect on human health (as prescribed in **Tables-1, 2 and 5**).
- 3.2 The drinking water shall be fairly clear (i.e., of low turbidity and color) and contain no compounds that cause offensive taste and odor and free of substances and organisms that cause corrosion or encrustation of water supply system as presented in **Table-3**.
- 3.3 When the guideline values are exceeded, it should only be a signal to investigate and take remedial action. Short-term exposure, however, does not necessarily mean that the water is unsuitable for consumption. The amount by which, and the period for which, the guideline value can be exceeded without affecting public health depends upon the specific substance involved and its concentration.

A continuous effort should be made to maintain drinking water quality at the highest possible level. Although the guideline value recommends the quality of water acceptable for consumption, it does not imply that the quality of drinking water should be degraded to the recommended level.

All desirable parameters and substances should be examined whenever a doubt arises. When a new water supply source develops it has to be examined before any supply.

In order to keep the uniformity of measurement results units of microbiological quality, physical parameters, chemical constituents and radioactive substances should be the same as presented in **Tables-1, 2,3,4 and 5**.

**Table-1 Bacteriological Quality**

No.	Substance	Guideline Value (G <sub>N</sub> )	Remark
<b>A</b>	<b>Treated Water Entering the Distribution System</b>		
1	<i>E.coli</i> or thermo tolerant Coliform bacteria	0/100 ml	Membrane filtration is recommended for low turbid water
2	Total Coliform Bacteria	0/100 ml	93.0 % of samples examined throughout the year
<b>B</b>	<b>Treated Water In the Distribution System</b>		
1	<i>E.coli</i> or thermo tolerant Coliform bacteria	0/100 ml	Membrane filtration is recommended for low turbid water
2	Total Coliform Bacteria	0/100 ml	93.0 % of samples examined throughout the year

**Table-2 Chemicals of Health Significance**

No.	Substance	Guideline (G <sub>N</sub> ) (mg/l)	Remark (Health Effect)
<b>A Inorganic Constituents</b>			
1	Arsenic	0.01 (P)	High incidence of skin & possibly other cancers
2	Barium	1.8	Increase blood pressure & suspect of cardiovascular diseases
3	Boron	0.3	Long-term exposure leads to gastrointestinal irritation
4	Cadmium	0.003	Kidney is the main target organ of toxicity
5	Chromium	0.10	Carcinogenicity suspect of chromium (VI) compounds
6	Copper	5	Acute gastric irritation & liver cirrhosis from long-term exposure
7	Cyanide	0.07	Acute toxicity is high. Effects on thyroid & particularly the nervous system on long-term exposure occurred.
8	Fluoride	3.0	At low conc. prevent dental carries. At high conc. increase risk of dental fluorosis, & much higher conc. leads to skeletal fluorosis.
9	Lead	0.02	Toxic to both the central & peripheral nervous systems, including subencephalopathic neurological effects.
10	Manganese	0.8	Neurotoxicity and other toxic effects
11	Mercury (total)	0.001	The kidney is the main target for inorganic Hg, whereas methyl-mercury affects mainly the central nervous system.
12	Nitrate (as NO <sub>3</sub> <sup>-</sup> )	50	Causes methaemoglobinaemia in infants and suspect of certain form of cancer risk
13	Nitrite (as NO <sub>2</sub> <sup>-</sup> )	6.0	” ” ” ”
14	Selenium	0.01	Long-term exposure cause toxic effect on nails, hairs and liver.
<b>B Organic Constituents</b>			
B1	Aromatic hydrocarbons	(µg/l)	
1	Benzene	10	Acute exposure at high conc. affects the central nervous system. At lower conc. it is toxic to haematopoietic system. Carcinogenic to humans (Group-1)
2	Benzo[a]pyrene	0.7	It causes cancer and induces tumors at the site of administration.
B2	Chlorinated alkanes		
1	Carbon tetrachloride	2	Possibly carcinogenic to humans (Group-2B)
2	1,2-dichloroethane	30	Possibly carcinogenic to humans (Group-2B)
B3	Chlorinated ethenes		
1	1,1-Dichloroethene	30	Potentially carcinogenic (Group-3)
2	Trichloroethene	70(P)	Potentially carcinogenic (Group-3)
3	Tetrachloroethene	40	Possibly carcinogenic to humans (Group-2B)

**Table-2 (Cont.)**

No.	Substance	Guideline (G <sub>N</sub> ) (mg/l)	Remark (Health Effect)
<b>C Pesticides</b>			
		(µg/l)	<b>Remark (Health Effect)</b>
1	DDT	2	Possibly carcinogenic to humans (Group-2B)
2	Aldrine/Deldrine	0.03	Potentially carcinogenic (Group-3)
3	Chlordane	0.2	Possibly carcinogenic to humans (Group-2B)
4	Pentachlorophenols	9 (P)	Potentially carcinogenic to lab animals.
5	2,4-D	30	Possibly carcinogenic to humans (Group-2B)
<b>D Disinfectant &amp; Disinfectant By-products</b>			
<b>D1</b>	<b>Disinfectant</b>	<b>(mg/l)</b>	<b>Remark (Health Effect)</b>
1	Chlorine	5	<ul style="list-style-type: none"> <li>For effective chlorination, free residual chlorine 0.5 mg/l after 30 min of contact time &amp; pH&lt;8</li> <li>Potentially carcinogenic (Group-3)</li> </ul>
<b>D2</b>	<b>Disinfectant By-products</b>	<b>(µg/l)</b>	
<b>D2.1</b>	<b>Chlorophenol</b>		
1	2,4,6-Trichlorophenol	200	Possibly carcinogenic to humans (Group-2B)
<b>D2.2</b>	<b>trihalomethane</b>		
1	Chloroform	200	Possibly carcinogenic to humans (Group-2B)

• P - Provisional guideline value (see WHO, Vol-1, p178)

• Group - is the IARC classification (see WHO, Vol-1, p35)

• The sum of the ratio of the concentration of (NO<sub>3</sub> & NO<sub>2</sub> to its respective guideline values should not exceed 1.



**Table-3 Substances and Parameters that may Give Rise to Complaints from Consumers**

No.	Substance	Guideline Value (G <sub>N</sub> ) (mg/l)	Remark (Adverse Effect)
<b>A Physical Parameters</b>			
1	True Color	22	Unpleasing appearance
2	Odor	Non-Objectionable	Unappealing to drink
3	Test	Non-Objectionable	Unappealing to drink
4	Temperature	Non-Objectionable	High temperature may enhance growth of micro organisms & may increase test, odor, color & corrosion
5	Turbidity	7	Stimulate after growth & cause objectionable appearance
<b>B Inorganic Constituents</b>			
1	Aluminum	0.4	Deposition of aluminum hydroxide flocks in pipes & exacerbation of discoloration of water by iron
2	Ammonia	2	Objectionable odor
3	Chloride	533	Undesirable taste
4	Copper	2	Increase corrosion of GI & steel fittings, staining laundry & sanitary ware and give rise taste problem.
5	Hardness	392*	Based on 300 as Reference WHO recommendation
6	Hydrogen Sulfide	0.07	Objectionable rotten egg odour
7	Iron	0.4	Cause reddish-brown color, promote iron-bacteria & stain laundry & plumbing fixtures
8	Manganese	0.13	Stain laundry & plumbing fixtures and give rise to undesirable taste to beverages. Deposited as black precipitate in pipes. Certain micro organisms concentrate to give taste, odor, & turbidity problem.
9	Dissolved Oxygen	-	Low DO encourage for anaerobic reaction & formation of NO <sub>2</sub> , H <sub>2</sub> S giving rise to odor. It also increase Fe(II).
10	pH	6.5 – 8.5	High pH imparts taste & soapy feel, while low pH cause corrosion. Preferably <8.0 for effective disinfection
11	Sodium	358	Undesirable taste
12	Sulfate	483	Causes noticeable taste & corrosion of pipes
13	TDS	1776	Undesirable taste
14	Zinc	6	Imparts astringent taste & opalescent and develop a greasy film on boiling.
<b>B Disinfectants &amp; Disinfectant by-products</b>			
	Disinfectants	(µg/l)	
1	Chlorine	600 – 1000	Taste and odour problem

\* There is no as such any Guideline figure set by WHO. However the maximum recommended value of 300 is taken for calculation.

**Table-4 Chemicals not of Health Significance at Concentration Normally Found in Drinking Water**

No.	Substance	Guideline Value (G <sub>N</sub> )	Remark
1	Asbestos		U
2	Silver		U
3	Tin		U

U – It is unnecessary to recommend a health-based guideline value, because they are not hazardous to human health at concentrations normally found in drinking water.

**Table-5 Radioactive Constituents of Drinking Water**

No.	Substance	Screening Value (Bq/litre)	Remark (Health Effect)
1	Gross alpha activity	0.1	<ul style="list-style-type: none"> <li>If a screening value exceeded, more detail radionuclide analysis is necessary. WHO &amp; other countries' is the same value.</li> <li>The main concern is Cancer</li> </ul>
2	Gross beta activity	1	

#### 4.0 SAMPLING TECHNIQUE

The detail procedure for preservation and handling of samples is presented in WHO, Vol-3 chapter-4 and ISO Water- Sampling- Part 3: Reference No. 5667-3:1994(E).

##### 4.1 General Requirement For Bacteriological Sampling

Sampling for bacteriological examination should be carried out using sterile container of glass or polyethylene. Samples should be preserved under low temperature of 2 to 5 °C during storage and transport. The time between sampling and analysis should not exceed 6 hours, and 24 hours is considered the absolute maximum. If ice is not available, the transport time must not exceed 2 hours.

The bacteriological test should be accompanied with turbidity and free residual chlorine and pH where chlorination is applied. The minimum recommended frequency of sampling and analysis for on spot and piped distribution water supply schemes are given in Table-6 and Table-7 respectively.

**Table-6 Minimum Frequency of Sampling and Analysis of On-spot Distribution Water Schemes**

Sources & Mode of supply	Minimum frequency of sampling & Analysis		Remarks
	Bacteriological	Physico-chemical	
HDW & shallow well with HP	Sanitary protection Bacteriological test only if situation demands	Once initially, thereafter as situation demands	The situation requiring testing are change in environmental conditions, outbreak of water born diseases, or increase in incidents of water born diseases
BH-with HP	Once initially, thereafter as situation demands	Once initially, thereafter as situation demands	Ditto
Protected spring	Once initially, thereafter as situation demands	Periodically for residual chlorine if water is chlorinated	Ditto

BH = Borehole, HDW = Hand-dug-well, HP = Hand-pump

**Table-7 Minimum Sample Numbers for Piped Drinking Water in the Distribution System**

Group	Pop served	No of Annual samples
1	<5000	2
2	5000-100,000	(Pop/5000) x 6
3	>100,000	(Pop/ 10,000) + 120

#### 4.2 General Requirement for Physico-Chemical Sampling

In general samples for physico-chemical analysis are recommended to be stored in a clean glass or polyethylene bottles at a low temperature in the dark (see **Table-8**). It is essential that the container should not be a cause of contamination and absorb or adsorb the constituents to be determined.

**Table-8 Allocation of Physico-chemical Parameters (of interest) to the Type of Preservation**

No.	Preservation by	Suitable for	Not Suitable for	Remarks
1	Acidification to pH<2	Alkali metals Aluminum  Ammonia  Arsenic  Alkali earth metal Nitrate  Total hardness Phosphorus, total Heavy metal	Cyanide Sulfides  Carbonates, bicarbonates, CO2 Nitrites	Don't use sulfuric acid for Calcium and lead.  Don't use hydrochloric acid for silver, lead and mercury.  Don't use nitric acid for tin.
2	Cooling to 2°C to 5°C	Alkalinity Ammonia Conductivity Nitrate Nitrite Odour Orthophosphates Sulfates Total residue		

Every newly developed source has to be tested for full physico-chemical analysis before any service. Then after, the sampling for piped system should be carried out in such a way that one sample should be taken every two years for ground water sources such as borehole, shallow-tube-well and spring.

Surface water intended for water supply source should be sampled at least 6 times per year per site to detect the maximum and minimum concentration of interest. Then after two full physico-chemical analyses per year is recommended.

In all water sources when situation demands testing should be done for important parameters. These special situations are change in environmental condition, outbreak of water born diseases or increase of water born diseases.

### 4.3 Identification and Records

The source of the sample and the conditions under which it was collected should be recorded and attached to the bottle immediately after filling. At least the following information should be included with the sample (See **Figure-1**).

**Figure-1 Suggested Form to Accompany Water Samples**

Water-quality monitoring program	
SAMPLING DATA	
1	Region
2	Zone
3	Wereda
4	Town/Village
5	Sampling site
6	Source
7	Nature of sample (Treated or non-treated)
8	Residual chlorine
9	Date of sampling
10	Time of sampling
11	Sampled by (Organization)

## 5.0 TESTING METHODS

The following test methods are selected mainly from ISO (International Organization for Standardization), based on WHO recommendation, to serve as reference test methods, in which every water quality laboratory in the country should develop towards it (see Table-9 to Table-13). International Organization for Standardization (ISO) is a worldwide federation of national standards bodies (ISO member bodies).

**Table-9 Bacteriological Quality of Drinking Water**

1	SUBSTANCE	REFERENCE	TEST METHOD
1	<i>E.coli</i> or thermo tolerant Coliform bacteria	ISO 9308-1:1990 or	Determination & enumeration of coliform organisms, thermo-tolerant <i>coliform</i> organisms and presumptive <i>escherchia coli</i> – Part 1: Membrane filtration method
		ISO 9308-2:1990	Determination & enumeration of coliform organisms, thermo-tolerant <i>coliform</i> organisms and presumptive <i>escherchia coli</i> – Part 2: Multiple Tube (MPN) method
2	Total Coliform bacteria	ISO 9308-1:1990 or	Determination & enumeration of coliform organisms, thermo-tolerant <i>coliform</i> organisms and presumptive <i>escherchia coli</i> – Part 1: Membrane filtration method
		ISO 9308-2:1990	Determination & enumeration of coliform organisms, thermo-tolerant <i>coliform</i> organisms and presumptive <i>escherchia coli</i> – Part 2: Multiple Tube (MPN) method

- Membrane filtration is recommended for low turbidity water

**Table-10 Substances and Parameters that May Give Rise to Complaints from Consumers**

1	SUBSTANCE	REFERENCE	TEST METHOD
<b>A</b>	<b>Physical Parameters</b>		
1	True Color	ISO 7887:1984(E)	Examination and Determination of Color
2	Odor	WHO, Vol-2, p358	Panel evaluation
3	Test	WHO, Vol-2, p358	Panel evaluation
4	Turbidity	ISO 7027:1990(E)	Determination of Turbidity
<b>B</b>	<b>Inorganic constituents</b>		
1	Aluminum	ISO 12020:1997(E)	Determination of Aluminum AAS method
2	Ammonia	ISO 7150-2:1986(E)	Determination of Ammonium Part2: Automated spectrophotometric method
3	Chloride	ISO 9297:1989(E)	Determination of Chloride – silver nitrate titration with chromate indicator (Mohr's method)
4	Copper	ISO 8280:1986(E)	Flam Absorption Spectrophotometric method
5	Hardness	ISO 6059:1984	Determination of the sum of calcium and magnesium - EDTA titrimetric method
6	Hydrogen Sulfide	WHO, Vol-2, p243	Methylene blue colorimetric method
7	Iron	ISO 6332:1988(E)	Determination of Iron - Spectrometric Method using 1,10-phenanthroline
8	Manganese	ISO 6333:1986(E)	Determination of Manganese Formaldoxime spectrometric method
9	DO	WHO, Vol-2, p324	Electrochemical probe or dissolved oxygen meter
10	pH	ISO 10523:1990(E)	Determination of pH
11	Sodium	ISO 9964-3: 1993(E)	Determination of Sodium and potassium by flam emission spectrophotometry
12	Sulfate	ISO 9280:1990(E)	Gravimetric method
13	TDS	WHO, Vol-2, p367	Conductivity probe
14	Zinc	ISO 8288:1986(E)	Flam Absorption Spectrophotometric method
<b>B</b>	<b>Disinfectant</b>		
1	Chlorine	ISO 7393-2:1985(E)	Determination of free chlorine and total chlorine using N,N-diethyly-1, 4 phylenediamine, for routine control process

**Table-11 Chemicals Of Health Significance**

1	SUBSTANCE	REFERENCE	TEST METHOD
A	Inorganic Constituents		
1	Arsenic	ISO 6595:1982(E)	Determination of total Arsenic – silver diethyl dithiocarbonate spectrophotometric method
2	Barium	WHO, vol-2, p175	AAS, using either direct aspiration into an air-acetylene flame or atomization in a furnace.
3	Boron	ISO 9390:1990(E)	Determination of Borate – spectrophotometric method using Azomethine-H
4	Cadmium	ISO 5961:1994(E) ISO 8288:1986(E)	Determination of cadmium – by AAS method Flam Absorption Spectrophotometric method
5	Chromium	ISO 11083:1994(E)	Determination of chromium (vi) – spectrometric method using 1,5-diphenylcarbazine
6	Copper	ISO 8288:1986(E)	Flam Absorption Spectrophotometric method
7	Cyanide	ISO 6703:1984(E)	Determination of cyanide- Part 1: Determination of total cyanide
8	Fluoride	ISO 10359-1:1992(E)	Electrochemical probe method - for potable and lightly polluted water
9	Lead	ISO 8288:1986(E)	Flam Absorption Spectrophotometric method
10	Manganese	ISO 6333:1986(E)	Determination of Manganese Formaldoxime spectrometric method
11	Mercury (total)	ISO 9965-3: 9984(E)	Determination of total mercury- by flameless AAS – method after digestion with bromine
12	Nitrate (as NO <sub>3</sub> <sup>-</sup> )	ISO 7890-3:1988(E)	Determination of nitrate- Part 3:spectrometric method using sulfosalicylic acid.
13	Nitrite (as NO <sub>2</sub> <sup>-</sup> )	ISO 6777:1984(E)	Determination of nitrite - Molecular Absorption spectrometric method
14	Selenium	ISO 9965:1993(E)	Determination of Selenium – AAS method (hydride technique)
B	Organic Constituents		
B1	Aromatic hydrocarbons		
1	Benzene	WHO, Vol-2, p462	A purge and trap gas chromatographic procedure with photoionization detection
2	Benzo[a]pyrene	WHO, Vol-2, p496	Gas chromatography in conjunction with mass spectrographic
B2	Chlorinated alkanes		
1	Carbon tetrachloride	WHO, Vol-2, p390	A purge and trap gas chromatography
2	1,2-dichloroethane	WHO, Vol-2, p411	A purge and trap gas chromatographic procedure
B3	Chlorinated ethenes		
1	1,1-Dichloroethene	WHO, Vol-2, p432	A purge and trap gas chromatographic procedure
2	Trichloromethene	WHO, Vol-2, p445	A purge and trap gas chromatographic procedure
3	Tetrachloroethene	WHO, Vol-2, p453	A purge and trap gas chromatographic procedure



**Table-11 (Cont. )**

C	Pesticides	Reference	Test Method
1	DDT	WHO, Vol-2, p639	Gas Chromatography with electron-capture detector.
2	Aldrine/Deldrine	WHO, Vol-2, p604	Extraction with pentane followed by Gas Chromatography with electron-capture detector
3	Chlordane	WHO, Vol-2, p628	Extraction with pentane followed by gas chromatography with electron capture detector
4	Pentachlorophenols	ISO 8165-1:1992(E)	Determination of selected monovalent phenols Part1: Gas-chromatographic method after enrichment by extraction
D	Disinfectant & disinfectant bi-product		
D1	Disinfectant		
1	Chlorine	ISO 7393-2:1985(E)	Determination of free chlorine and total chlorine using N,N-diethyly-1, 4 phylenediamine, for routine control process
D2	Disinfectant By-products		
D2.1	Chlorophenol		
1	2,4,6-Trichlorophenol	ISO 8165-1:1992(E)	Determination of selected monovalent phenols-Part 1: Gas chromatographic method after enrichment by extraction
D2.2	Trihalomethane		
1	Chloroform	WHO, Vol-2, p850	Gas chromatography- with detection by flame ionization, electron-capture, or mass spectroscopy

**Table-12 Chemicals not of Health Significance at Concentration normally Found In Drinking Water**

1	SUBSTANCE	REFERENCE	TEST METHOD
1	Asbestos	WHO, Vol-2, p168	Transmission electron microscopy (TEM) with identification by energy depressive X-ray analysis and selected-area electron diffraction (TEM/SAED)
2	Silver	WHO, vol-2, p339	Spectrographic and colorimetric method with diithi-zone
3	Tin	WHO, vol-2, p361	AAS either direct aspiration into a flame or furnace technique

**Table-13 Radioactive Constituents of Drinking Water**

<sup>1</sup>	SUBSTANCE	REFERENCE	TEST METHOD
1	Gross alpha activity	ISO 9696:1992	Measurement of Gross Alpha activity in non-saline water - thick source method.
2	Gross beta activity	ISO 9697:1992	Measure of gross beta activity in non-saline water

## 6.0 SANITARY INSPECTION

Sanitary survey and WQ analysis are complementary activities that should be conducted by both the water supply agency as well as surveillance agency. The sanitary inspection forms, prepared in the form of checklist, are possible to determine an overall measure of the sanitary state of the supply.

### 6.1 Frequency of Sanitary Inspection

One of the most important surveys is that undertaken when new water sources are developed. When alternative water sources are under consideration, each should be surveyed. The guiding principle is that no new water supply should be approved without a sanitary inspection. Routine surveys of existing supplies should be undertaken periodically as stated in **Table-14** by the community, water supplier and surveillance agency.

**Table-14 Minimum Annual Frequency of Sanitary Survey**

<sup>1</sup>	Source & Mode of Supply	Community	Water-supply Agency	Surveillance Agency
<b>1.0</b>	<b>On Spot supply</b>			
1.1	Hand-dug well (Without windlass)	6	-	-
1.2	Hand-dug well (With windlass)	6	-	-
1.3	Dug well with hand-pump	4	-	0.5
1.4	Shallow & deep tube well with hand-pump	4	-	0.5
1.5	Gravity spring	4	-	0.5
<b>2.0</b>	<b>Piped Supply</b>			
2.1	Groundwater with & without chlorination	-	0.5	0.5
2.2	Treated surface water with chlorination:			
	<5,000 Pop	-	0.5	0.5
	5,000 to 20,000 Pop	-	1	0.5
2.3	Distribution system of piped supply	-	6	0.5