PART 2 ANALYSIS OF NATURAL ENVIRONMENT

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DP 2.1 Hydrology and Meteorology

2.1.1 Climate

The climate of Madagascar Island is influenced by the tropical low-pressure system from the north and the subtropical high-pressure system from the southeast. The climate can be classified into two seasons. One is the dry season dominated by the subtropical high pressure system with low temperature starting in May and ends in October, and the other is the rain season dominated by the tropical low pressure system having high temperature starting in November and ends in April.

The topographic features influence the amount of precipitation. Eastern part of the Island has much precipitation influenced by the southeasterly trade wind. On the other hand, western part of the Island has less precipitation and it makes the area dry.

The Study Area, situated in the southern region of the island, is within the Savanna Climatic classification. The area is out of the range of the area having influence of the tropical low-pressure system, and also, topographically, the mountains of the Faut Dauphine region to the east block the wet trade winds to be influenced. This unique location makes up the area to have the least amount of precipitation in the country.

Within the Study Area, there are several meteorological stations. However, according to the responsible official in the Department of Meteorology, at present all the meteorological stations in this area are closed due to aging of equipment. Table 2.1.1-1 shows the list of meteorological stations around the Study Area and the available period of the observed data.

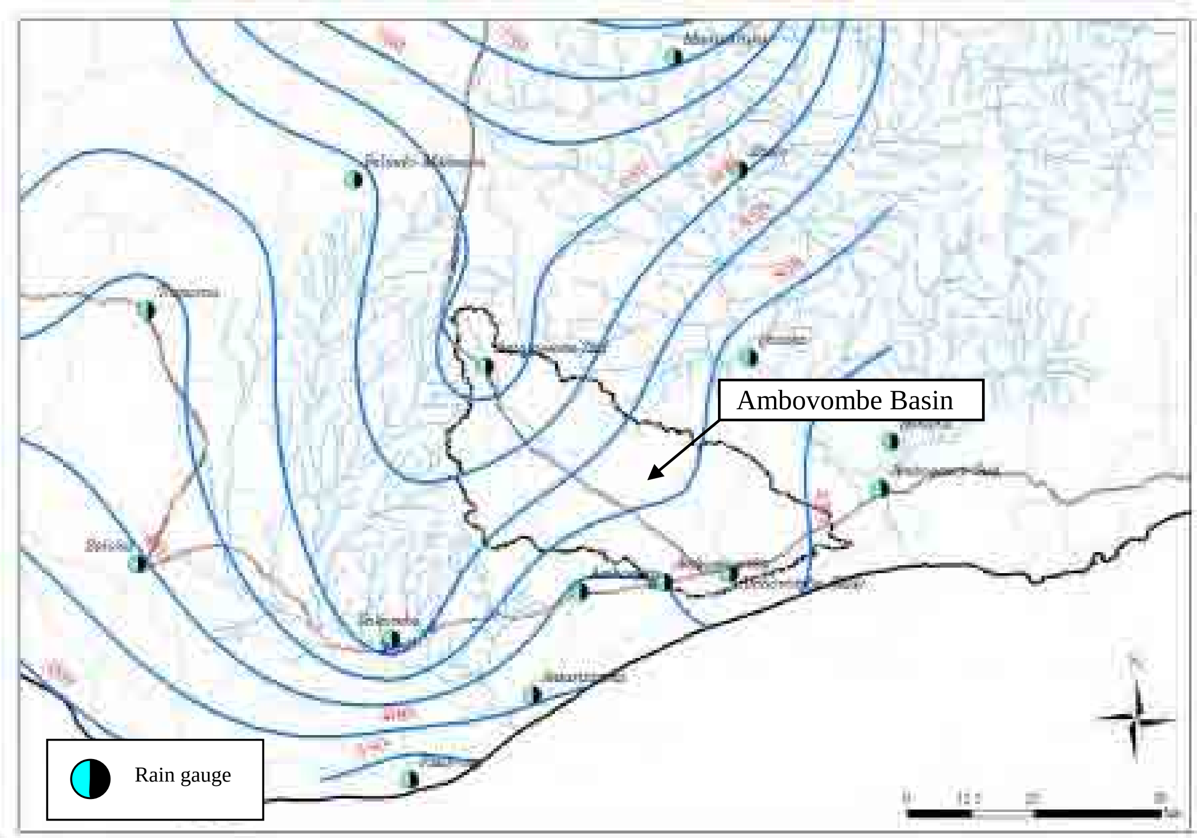
Table 2.1.1-1 List of Meteorological stations

Station	Category	Available period of data	Status
Amboasary Sud	Meteorological Station	From 1976 to 1985, 1997 and 1998	Closed
Ambovombe	Meteorological Station	From 1960 to 1986.	Closed
Antanimora	Meteorological Station	From 1957 to 1986.	Closed
Ambondro	Rainfall Station	From 1950 to 1991.	Closed
Antaritarika	Rainfall Station	From 1960 to 1976.	Closed
Tsihombe	Meteorological Station	From 1932 to 1968	Closed

Source: Department of Meteorology

Meanwhile from 1997, the organization named SAP (Systeme d'Alerte Precoce) has been taking on the role to maintain rain gauge stations within the south end area of Madagascar and to continue monitoring of rainfall. SAP is the organization supported by EU and they give warning of drought for south end area by analyzing only rainfall data.

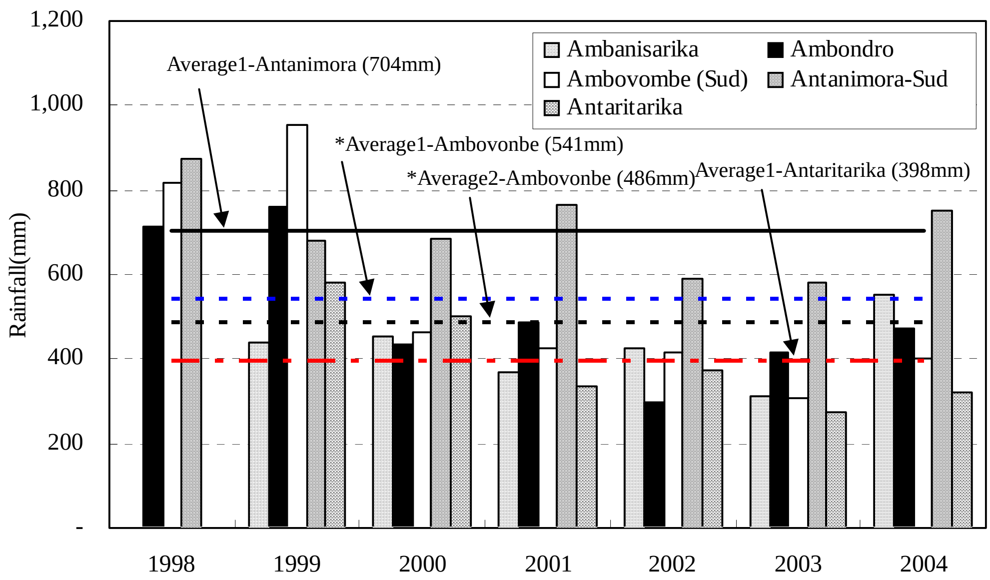
All the metereological stations, which are listed in the Table 2.1.1-1 are well maintained by SAP and the rainfall data of them from 1997 to the latest period is collected. As a reference, the data surrounding the Study Area are also collected. Figure 2.1.1-1 shows isohyet map around the Study Area which is generated with the collected data.



Source : SAP

Figure 2.1.1-1 Isohyet Map around the Study Area (Average of 1999-2004)

Figure 2.1.1-2 shows annual precipitation data of five rain gauge stations within the Study Area.

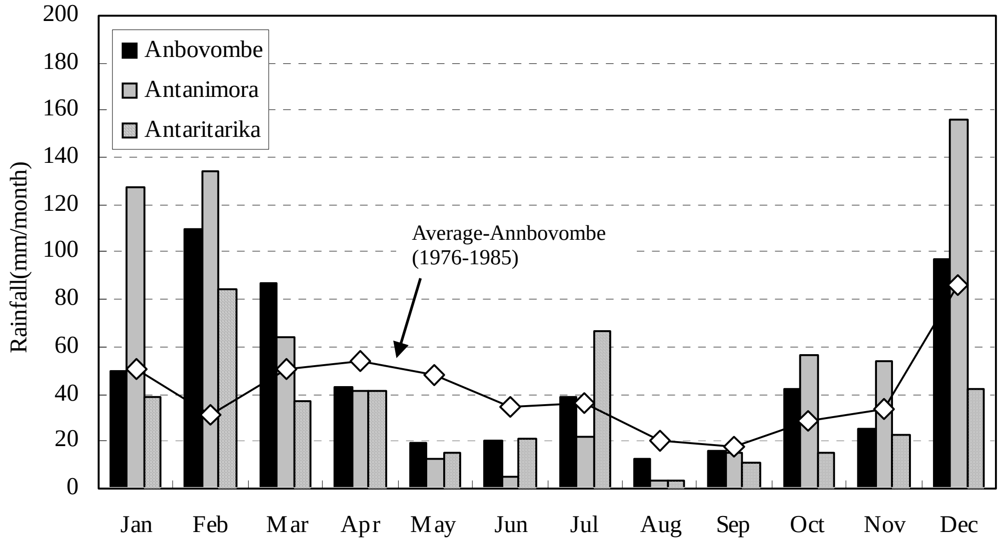


*Average1; 1998-2004, Average2; 1976-1985
Source: SAP

Figure 2.1.1-2 Annual Precipitation of the Stations within the Study Area (1998-2004)

In the Figure, average of annual precipitation, from 1998 to 2004, for Antanimora, Ambovombe and Antaritarika station and from 1976 to 1985 for Ambovombe station, is also shown. The figure shows the trend of precipitation that northern part of the Study area, Antanimora, has much precipitation than the southern part, Antaritarika. Average precipitation of Ambovombe station from 1998 to 2004 is relatively higher than the average from 1976 to 1985. For Ambovombe and Antaritarika station, annual precipitation measured from 2001 to 2004 is smaller than the average of annual precipitation from 1998 to 2004.

Figure 2.1.1-3 shows the average monthly precipitation of 1998 to 2004, for Antanimora, Ambovombe and Antaritarika station. In the figure, long term average monthly precipitation, from 1976 to 1985, for Ambovombe station is also shown.



Source: SAP

Figure 2.1.1-3 Monthly precipitation of the stations within the Study Area (1998-2004)

From the above figure it can be observed that most of the annual precipitation occurs between December and March, with December having the largest precipitation, and August being the lowest. Also, for Ambovombe, in comparison with the monthly average of the past data (1976 - 1985), the average of the recent years, the amount of precipitation seems to have fallen especially in the dry season.

2.1.2 Hydrology

Around the Study Area there are two large rivers. One is the Mandrare River flowing in the east, and the other is the Mananbovo River flowing in the west. Ambovombe Basin is located between these two rivers and there are no river flowing continuously throughout the year flowing out to the sea within the Ambovombe Basin, and river flows can only be observed during the wet season. Figure 2.1.2-1 shows the river system around the Study Area.

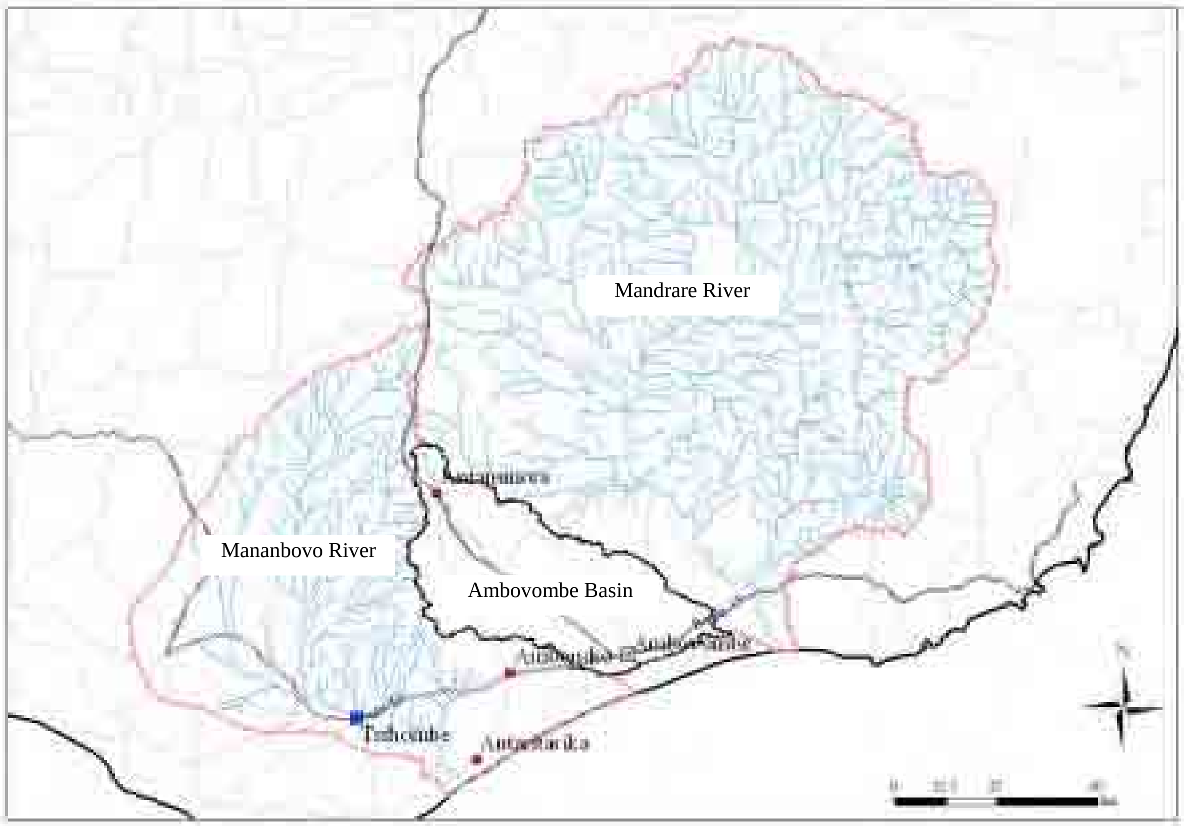


Figure 2.1.2-1 River systems around the Study Area

(1) Mandrare River

The Mandrare River is 270 km in length and has around 13,000km^2 of contributory area. The average altitude of the river basin is around 400m above sea level. The river flow can be observed throughout the year due to much amount of precipitation. Figure 2.1.2-2 shows location map of river gauge stations within the basin. Table 2.1.2-1 shows list of river gauge stations and the available period of the observed data.

Table 2.1.2-1 List of River Gauge stations

Station	Period of available data	Status
Amboasary-sud	From 1951 to 1986 and from 1994 to 1996	Closed
Andabolava-sa	From 1949 to 1971	Closed
Andabolava-sav	From 1967 to 1980	Closed
Bevia	From 1951 to 1974	Closed
Amboasary-est	From 1960 to 1961 and from 1974 to 1993	Closed
Ambia	From 1974 to 1975	Closed
Marotsiraka	1960 and from 1981 to 1983	Closed
Beraketa	From 1973 to 1978 ,from 1981 to 1983, from 1987 to 1989, and from 1990 to 1993	Closed
Andetsy	From 1950 to 1978	Closed
Ampastmpolaka	From 1973 to 1977	Closed
Ifotaka	From 1953 to 1976	Closed
Berenty	From 1974 to 1975	Closed

Source: Department of Meteorology

Figure 2.1.2-2 Location map of River gauge station within the Mandrare River basin

According to the responsible official in the department of meteorology, these river gauge stations have been also closed due to the same reason for the meteorological stations. Figure 2.1.2-3 shows monthly average discharge from 1951 to 1996.

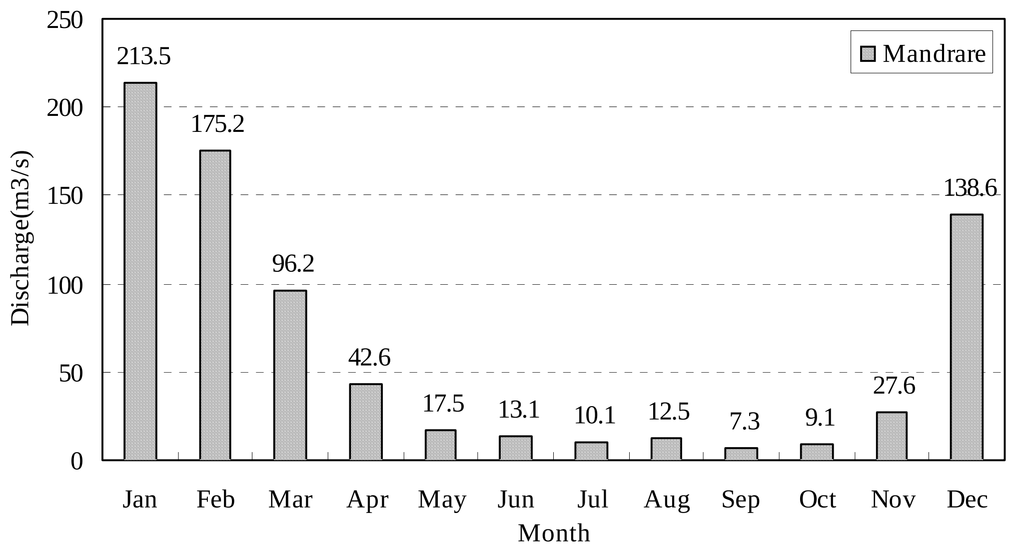


Figure 2.1.2-3 Monthly average discharge of the Mandrare River

From the figure it can be seen that even in the dry season there are certain amount of discharge in this river. Figure 2.1.2-4 shows the picture of Mandrare river which was taken in the middle of May at Amboasary.

Figure 2.1.2-4 Picture of the Mandrare River (middle of May, 2005)

(2) Mananbovo River

The Mananbovo River has around 4,450km^2 of contributory area and its length is 165km long. In the dry season there is no discharge observed in this river due to insufficient amount of precipitation. There is only one river gauge station in the city of Tsihombe. Figure 2.1.2-5 shows location map of river gauge stations within the basin. Table 2.1.2-2 shows list of river gauge station and available period of the observed data.

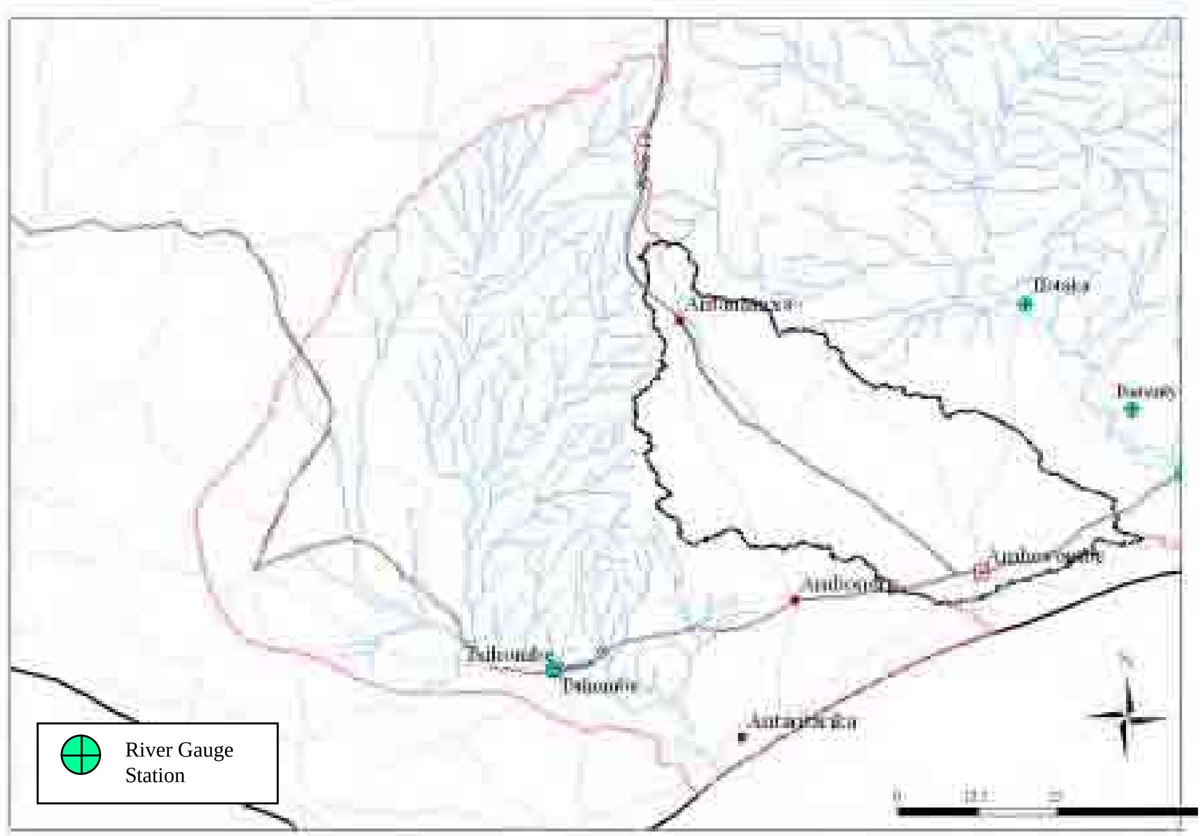


Figure 2.1.2-5 Location map of River gauge station within the Mananbovo River basin

Table 2.1.2-2 List of river gauge station

Station	Period of available data	Status
Tsihombe	From 1962 to 1983, from 1987 to 1989 and from 1995 to 1996	Closed

Source: Department of Meteorology

According to the Department of Meteorology, this river gauge station has been also closed due to the same reason of other stations. Figure 2.1.2-6 shows monthly average discharge of the Mananbovo River from 1962 to 1996.

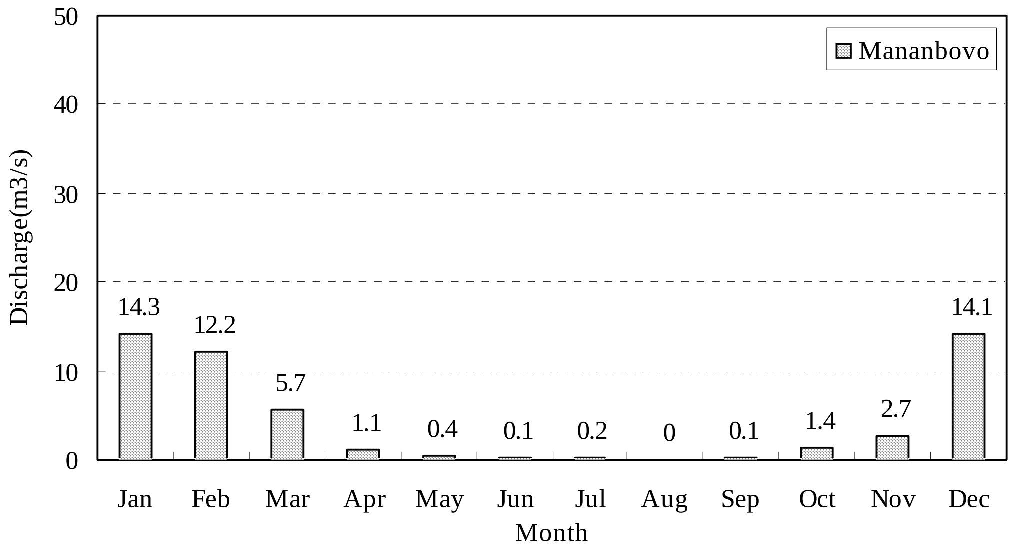


Figure 2.1.2-6 Monthly average discharge of the Mananbovo River

From the figure it can be seen that in the dry season there are only little discharge in this river. Figure 2.1.2-7 shows the picture of the Mananbovo River which was taken in the end of April 2005 at Tsihombe.

Figure 2.1.2-7 Picture of the Mananbovo River (end of April, 2005)

In the dry season, when river discharge becomes zero, people dig river bed to get water from the river.

(3) Ambovombe Basin

Within the Ambovombe Basin, there are several streams that occur only during the rainy season. However there are no observed data for such streams. Figure 2.1.2-8 shows location map of the Bemanba River that flows from northwestern part of Ambovombe Basin to the center of the basin. Through the site reconnaissance, which was undertaken in the middle of May 2005, no apparent discharge was confirmed. On the Figure 2.1.2-8, three locations which were visited during the reconnaissance are marked. Findings at the locations through the reconnaissance are as follows.

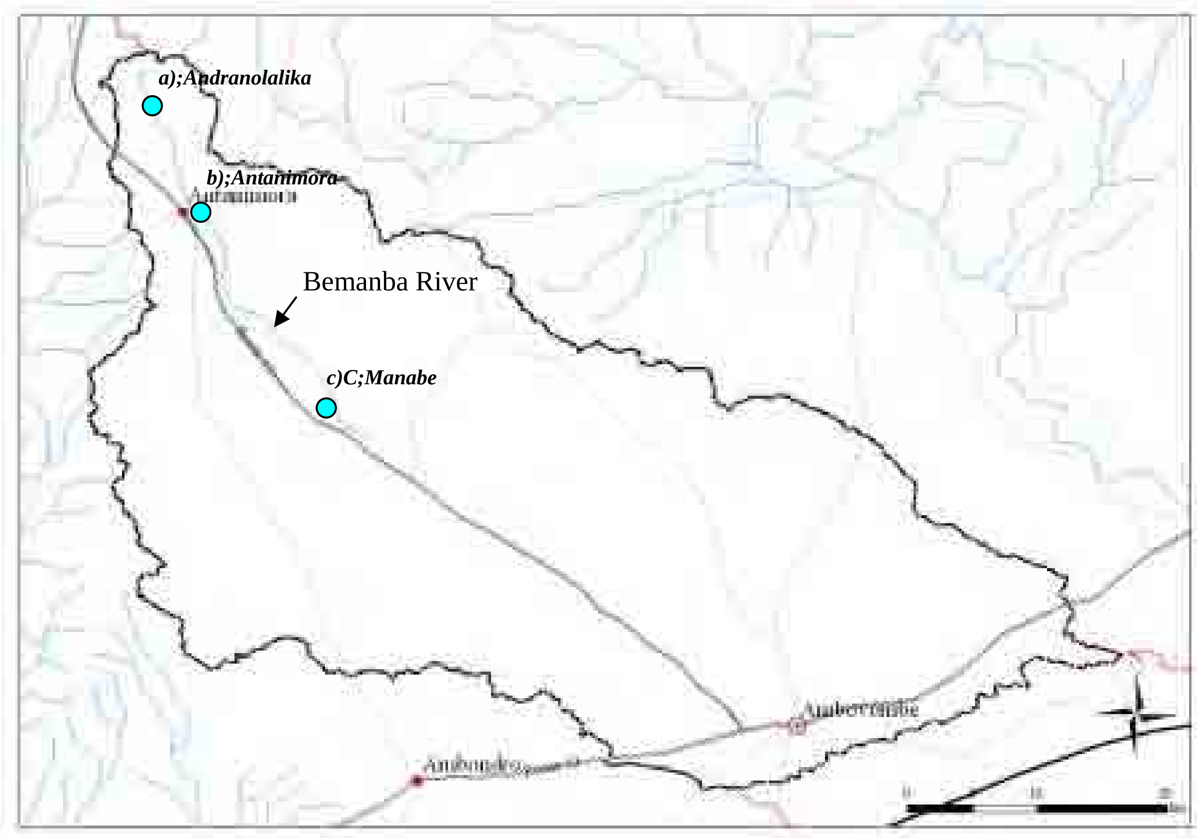


Figure 2.1.2-8 Map of streams within Ambovombe Basin

a) Andranolalika

This point is located in the headstream of the River. At this point, several seepages were seen along the River. Figure 2.1.2-9 shows the condition of this point. According to the local people, they can obtain water from this river throughout the year.

Figure 2.1.2-9 Picture of the Bemanba River (Andranolalika)

b) Antanimora

This point is located in the middle of the River. At this point, there are also several seepages along the River. Figure 2.1.2-10 shows the condition of this point. According to the local people, during the dry season, people get water from a dug hole in the river bed 1.5m deep. During the rainy season, after heavy precipitation, large stream flow appears and run off to the downstream rapidly.

Figure 2.1.2-10 Picture of the Bemanba River (Antanimora)

c) Manabe

This point is located in the downstream end of the River. At this point, there are no seepages along the River. Figure 2.1.2-11 shows the condition of this point. According to the local people, people can obtain water only from the neighboring well. Discharges occur only after heavy precipitation.

Figure 2.1.2-11 Picture of the Bemamba River (Manave)

DP 2.2 Geophysical Survey Analysis

2.2.1 General

The objective of the Geophysical Survey is to understand the geometry and distribution of geological structure in the study area. Three types of techniques were applied for the study. Table 2.2.1-1 shows the general information for the applied technique of the geophysical survey.

Table 2.2.1-1 Applied Techniques for the Geophysical Survey

Name of Technique	Objectives and principles	Surveyed Area
VES Survey (Vertical Electric Sounding)	➢ To understand basic geological structure within the study area. ➢ Resistivity of subsurface layer is measured by this survey.	Surveyed points are located to cover the whole study area
IP Survey (Induced Polarization Method)	➢ To understand distribution of weathered or fractured zone within the study area. ➢ Induced polarization value of subsurface layer is measured by this survey. ➢ Resistivity of subsurface layer is also measured by this survey.	Surveyed lines are mainly located in northern part of the study area (Basement Rock Area)
TEM Survey (Time-Domain Electromagnetic Method)	➢ To understand distribution of weathered or fractured zone within the study area. ➢ Resistivity of subsurface layer is measured by this survey.	Surveyed points are mainly located in northern part of the study area and southern coastal area

2.2.2 Vertical Electric Sounding (VES) Survey

(1) Methodology

This method measures resistivity of the subsurface layer. This survey is based on the evaluation of apparent resistivity of subsurface layer by passing a given electric current through current electrodes driven into the ground. The voltage is measured with two electrodes located in a line between those current electrodes. The apparent resistivity is given by the ratio of voltage to current times a spacing factor. Figure 2.2.2-1 shows typical arrangement of the VES survey (Wenner arrangement).

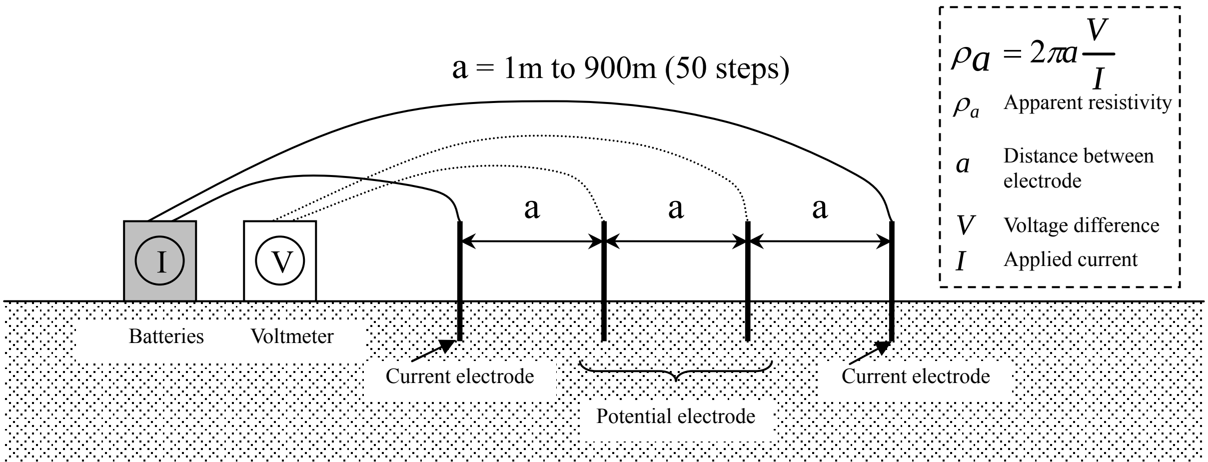


Figure 2.2.2-1 Typical Arrangement of IP Survey

The penetration's depth of electric current can be arranged by changing the distance of the current electrodes. By increasing the electrode spacing, deeper penetration's depth of the electric current can be obtained. During the field works, the computed data of (ρa) are presented in graphic in the form of field resistivity curve by plotting the (ρa) against (a/2) on the double logarithmic paper. This field curve is used for interpretation to compute the true resistivity of the rock layers. Table 2.2.2-1 shows list of equipments that were used for this survey.

Table 2.2.2-1 List of Equipment for VES Survey

Equipment	Type	Product	Specification		Quantity
Electric Resistivity Sounding Instrument	SYSCAL R2	2RS	Sensitivity	: 10μV	1
			Input Impedance	: 10MΩ	
			Max. Electric power	: 1,600 W	
			Out put voltage	: 800 V	
			Out put currency	: 2,000mA	
Battery					1
Electrode			Stainless stick 10mm dia. 60cm long		12
Electric cable			1.25mm dia.		1,500m

In the Study, this method is introduced to understand basic geological structure of study area. The exploration depth is set to 300m.

(2) Surveyed points

200 points are selected to cover the study area. First, the points were plotted on the map by drawing a 5 km mesh covering the whole study area. Then, the surveyor selects the actual survey point considering the surface condition around the prepared referential point. Special emphasis was considered around the Urban Ambovombe, regarded as an important groundwater production area, survey points were located densely. Figure 2.2.2-2 shows location map of surveyed point.

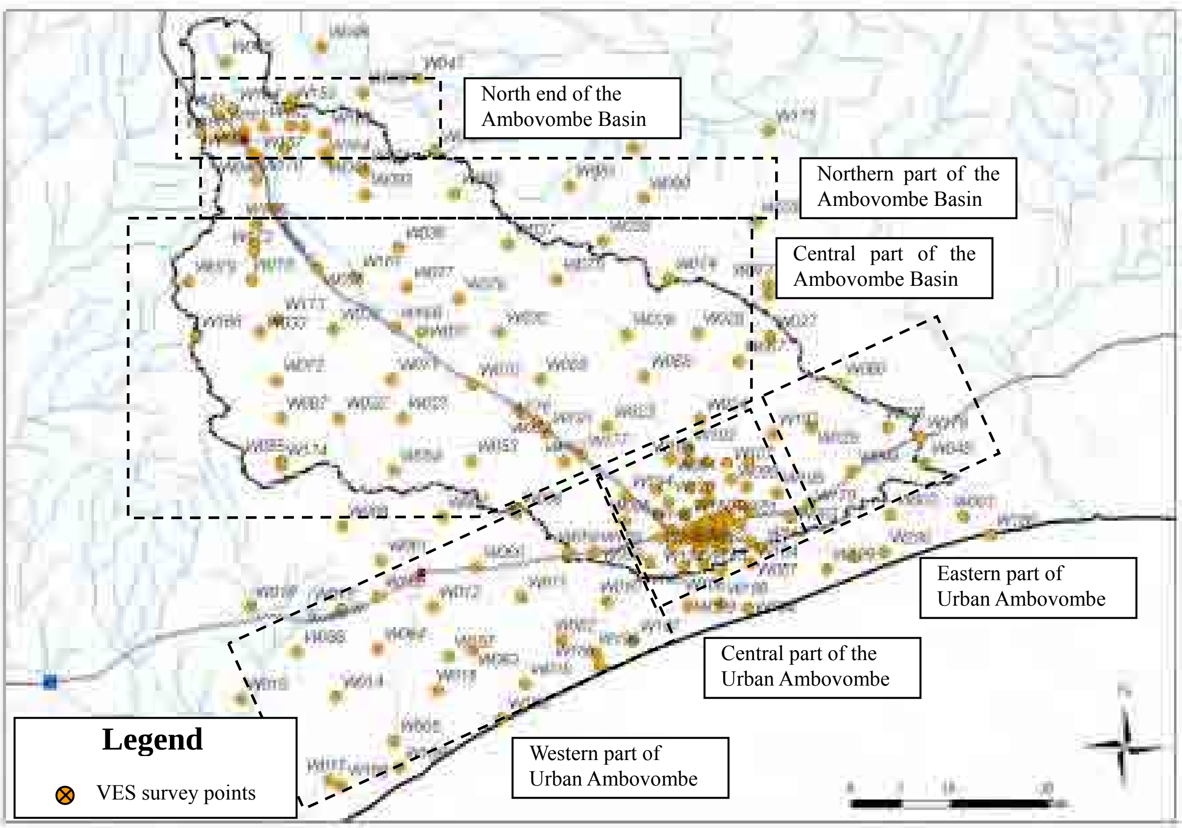


Figure 2.2.2-2 Location map of VES survey points

(3) Interpretation for the measurement data

Results of the interpretation for surveyed data are described for six (6) areas which are shown in the Figure 2.2.2-2. The results are also described in terms of following three classifications of subsurface layer: i) basement rock, ii) water bearing formation and iii) impermeable layer.

a) Central part of the Ambovombe Commune

Figure 2.2.2-3 shows enlarged view of the location of VES surveyed points in the central part of Ambovombe Commune.

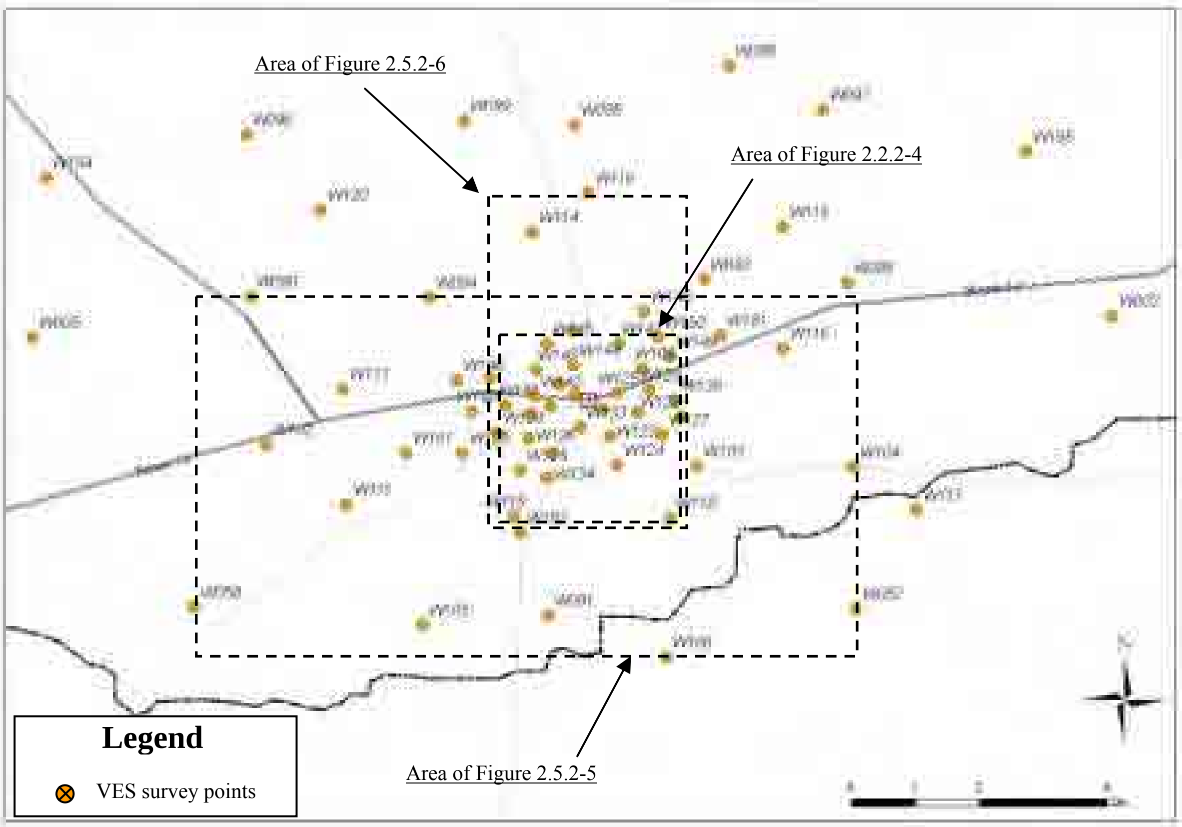


Figure 2.2.2-3 Enlarged view of VES survey points in the center of the Ambovombe Commune

i) Distribution of basement rock

Thickened low resistivity layer, less than 10 (ohm-m), is measured above basement rock. Due to existence of this layer, determination of the exact depth of basement rock is difficult. Resistivity of basement rock is rather low, less than 100(ohm-m), compared with usual rock layer and it indicates that the basement rock is comprised of slate or sand stone. However, such a low resistivity layer is sometimes influenced by the existence of saline water. Accordingly further examination such as test drilling is needed to conclude the distribution of basement rock in this area. Table 2.2.2-2 shows the interpreted elevation of basement rock for surveyed points of this area.

Table 2.2.2-2 Interpreted elevation of basement rock

Surveyed Points	Elevation (m)	Elevation of the top of the layer(m)	Depth to the top of layer(m)
W109	143	87	56
W119	130	60	70
W123	139	39	100
W124	143	59	84
W125	142	68	74
W126	147	72	75
W127	143	89	54
W128	136	92	44
W129	136	77	59
W130	144	69	75
W131	100	-10	110
W132	137	115	22
W133	147	85	62
W134	148	38	110
W135	138	28	110
W136	148	90	58
W137	140	74	66
W139	132	-18	150
W142	136	87	49
W144	139	68	71
W147	131	43	88
W148	128	87	41

Contour map of the dept to the top of interpreted basement rock is shown in the Figure 2.2.2-4. The area of this contour map is shown in the Figure 2.2.2-3.

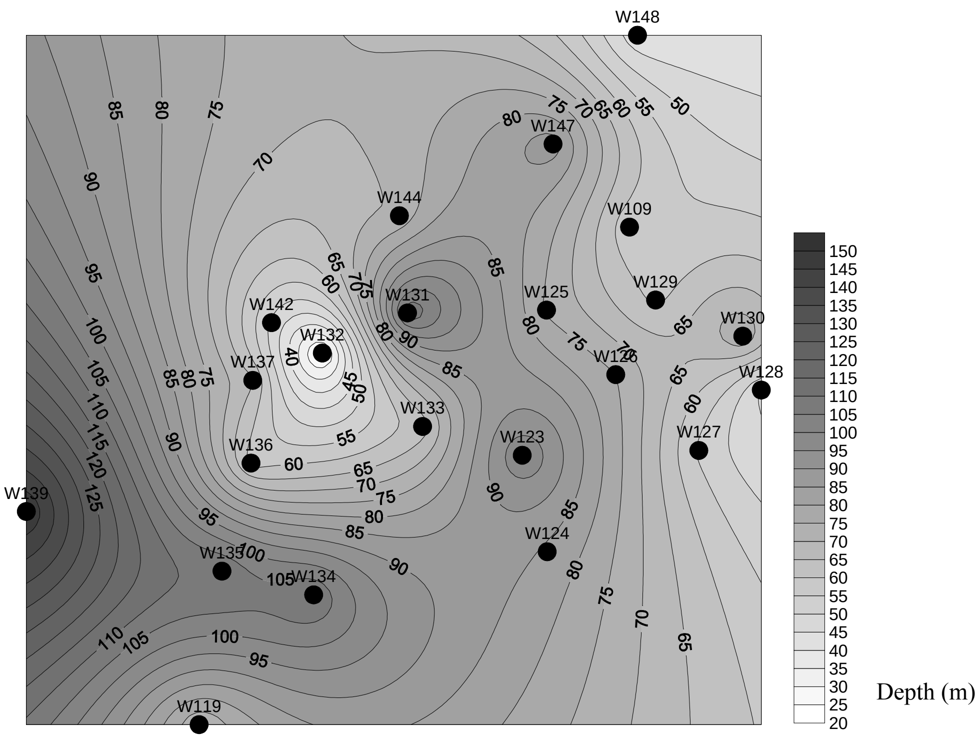


Figure 2.2.2-4 Contour map of the depth to the top of basement rock

ii) Distribution of water bearing formation

Existence of water bearing formation is figured out at the several surveyed points in the south western part of urban Ambovombe. High resistivity layer is measured above low resistivity layer which is interpreted as impermeable layer. Hence the high resistivity layer is interpreted as possible water bearing formation, such as sand or gravel.

These points which indicate the existence of water bearing formation is located around the center of the urban Ambovombe. Table 2.2.2-3 shows the interpreted depth and thickness of water bearing formation for surveyed points of this area.

Table 2.2.2-3 Interpreted depth and thickness of water bearing formation

Surveyed Points	Elevation (m)	Elevation of the layer(m)	Depth of the layer (m)	Thickness (m)
W121	189	175～69	14～120	96
W102	187	173～105	14～82	68
W111	167	147～67	20～100	80
W105	178	162～88	16～90	74
W106	169	133～49	36～120	84
W103	162	126～42	36～120	84
W104	202	182～134	20～68	48
W014	115	112～102	3～13	10
W057	169	165.4～153	3.6～16	12.4
W058	195	185～71	10～24	14

Contour map of the thickness of interpreted water bearing formation is shown in the Figure 2.2.2.2. The area of this contour map is shown in the Figure 2.2.2-3.

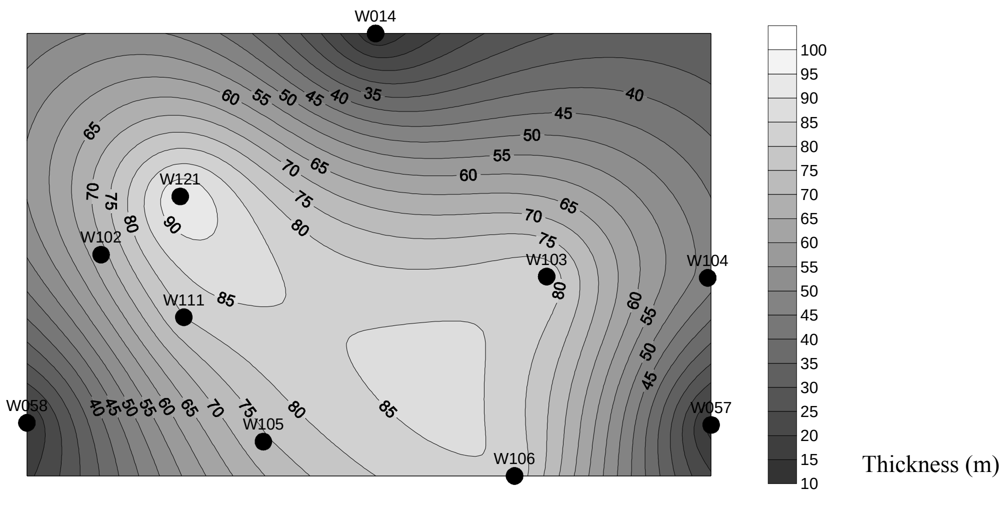


Figure 2.2.2-5 Contour map of the thickness of water bearing formation

iii) Distribution of impermeable layer

Low resistivity layer which distributes under interpreted water bearing formation or above the basement rock is considered as impermeable layer. Contour map of the thickness of interpreted impermeable layer is shown in the Figure 2.2.2-6. The area of this contour map is shown in the Figure 2.2.2-3.

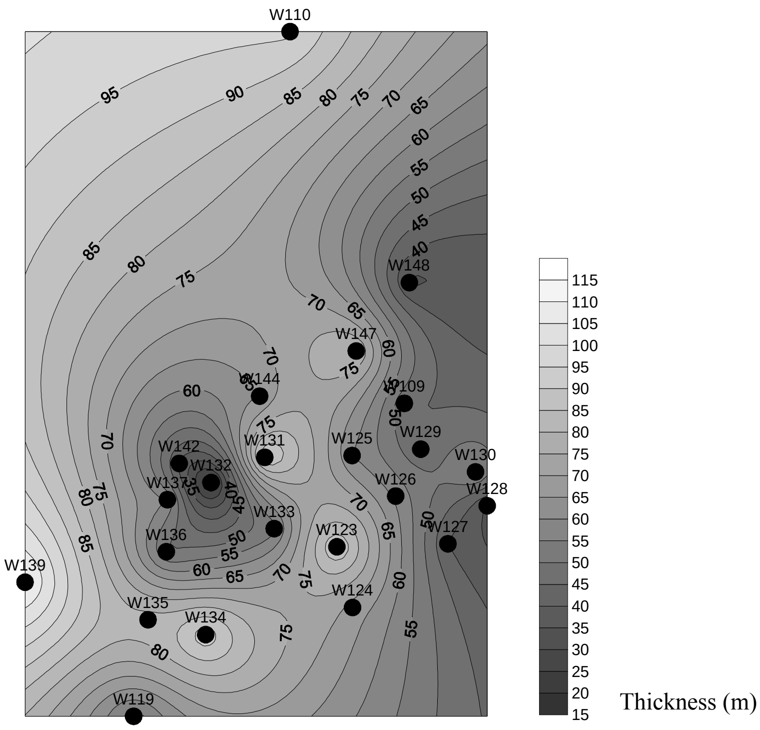


Figure 2.2.2-6 Contour map of the thickness of impermeable layer

b) Western part of the Ambovombe Commune

Figure 2.2.2-7 shows enlarged view of the location of VES surveyed points in the western part of Ambovombe Commune.

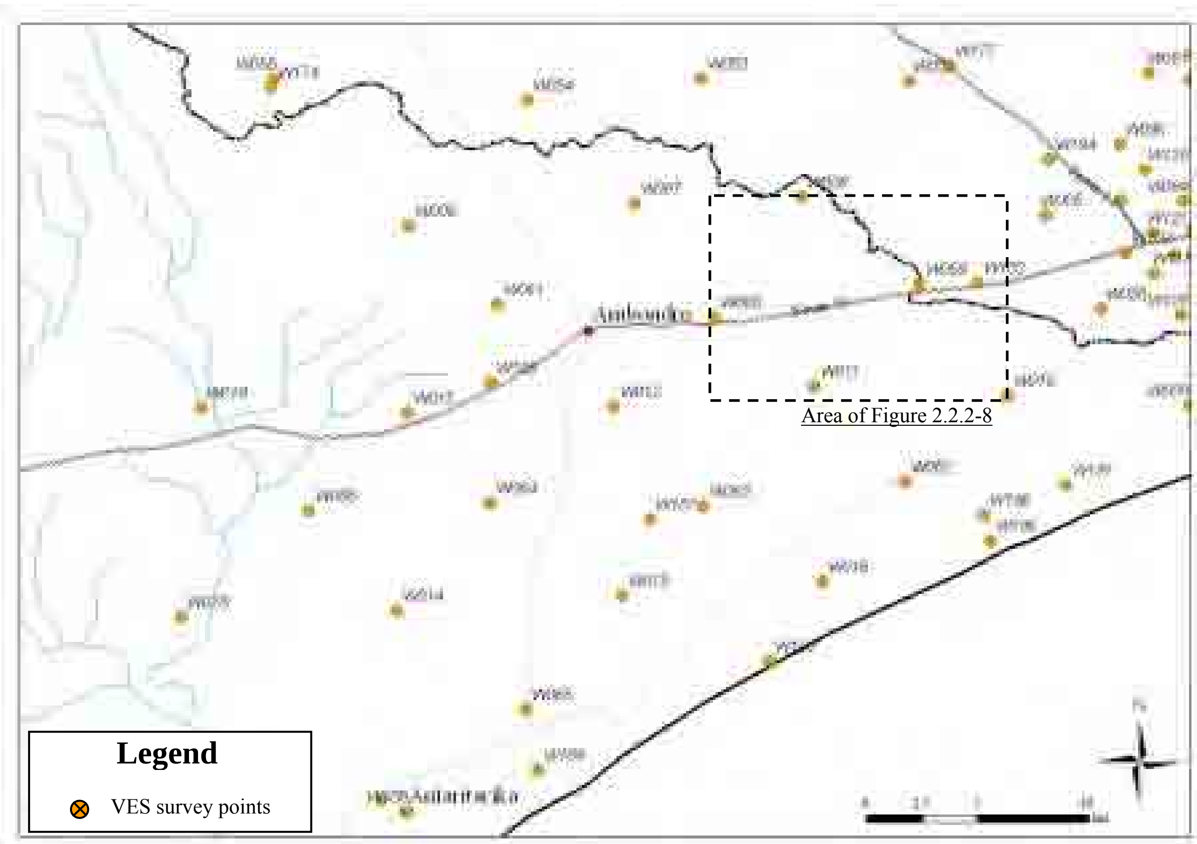


Figure 2.2.2-7 Enlarged view of VES survey points in the western part of Ambovombe Commune

i) Distribution of basement rock

Basement rock is figured out under the low resistivity at several surveyed points in the eastern part of this area. Table 2.2.2-4 shows the interpreted elevation of basement rock for surveyed points of this area.

Table 2.2.2-4 Interpreted elevation of basement rock

Surveyed Points	Elevation (m)	Elevation of the top of the layer(m)	Depth to the top of layer(m)
W007	205	153	52
W061	223	155	68
W064	142	-38	180
W014	115	-65	180
W018	71	9	62

ii) Distribution of water bearing formation

Existence of water bearing formation is figured out at the several surveyed points along national road 13. High resistivity layer is measured above low resistivity layer which is interpreted as impermeable layer. Hence the high resistivity layer is interpreted as possible water bearing formation, such as sand or gravel. Table 2.2.2-5 shows the interpreted depth and thickness of water bearing formation for surveyed points of this area.

Table 2.2.2-5 Interpreted depth and thickness of water bearing formation

Surveyed Points	Elevation (m)	Elevation of the layer(m)	Depth of the layer (m)	Thickness (m)
W006	227	215～189	12～38	26
W010	204	175～162	29～42	13
W059	204	194～150	10～54	44
W060	208	194～152	14～56	42

Contour map of the thickness of interpreted water bearing formation is shown in the Figure 2.2.2-8. The area of this contour map is shown in the Figure 2.2.2-7.

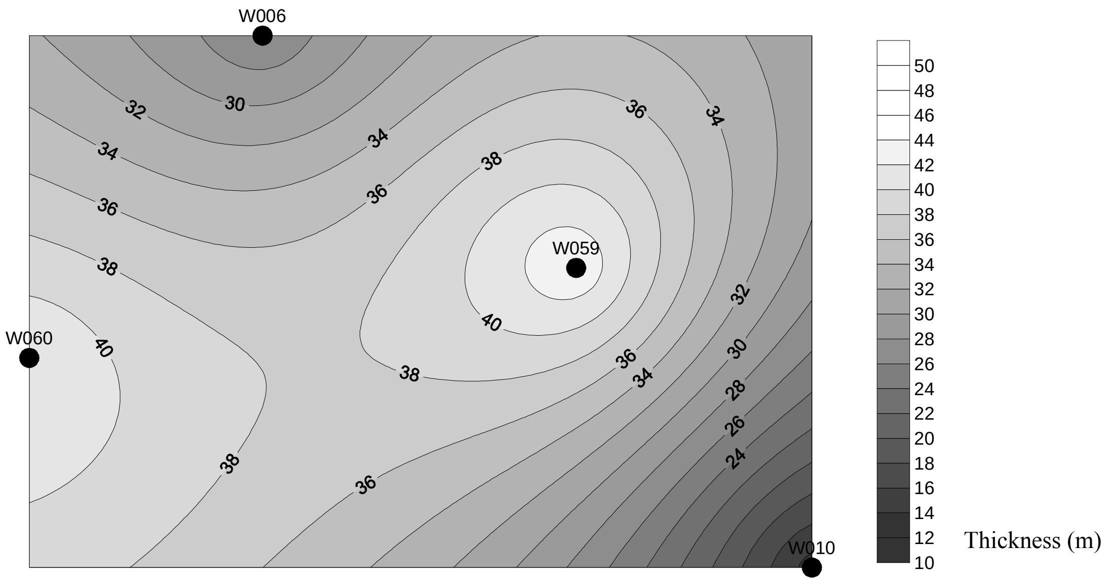


Figure 2.2.2-8 Contour map of the thickness of water bearing formation

c) Eastern part of Ambovombe Commune

Figure 2.2.2-9 shows enlarged view of the location of VES surveyed points in the eastern part of urban Ambovombe.

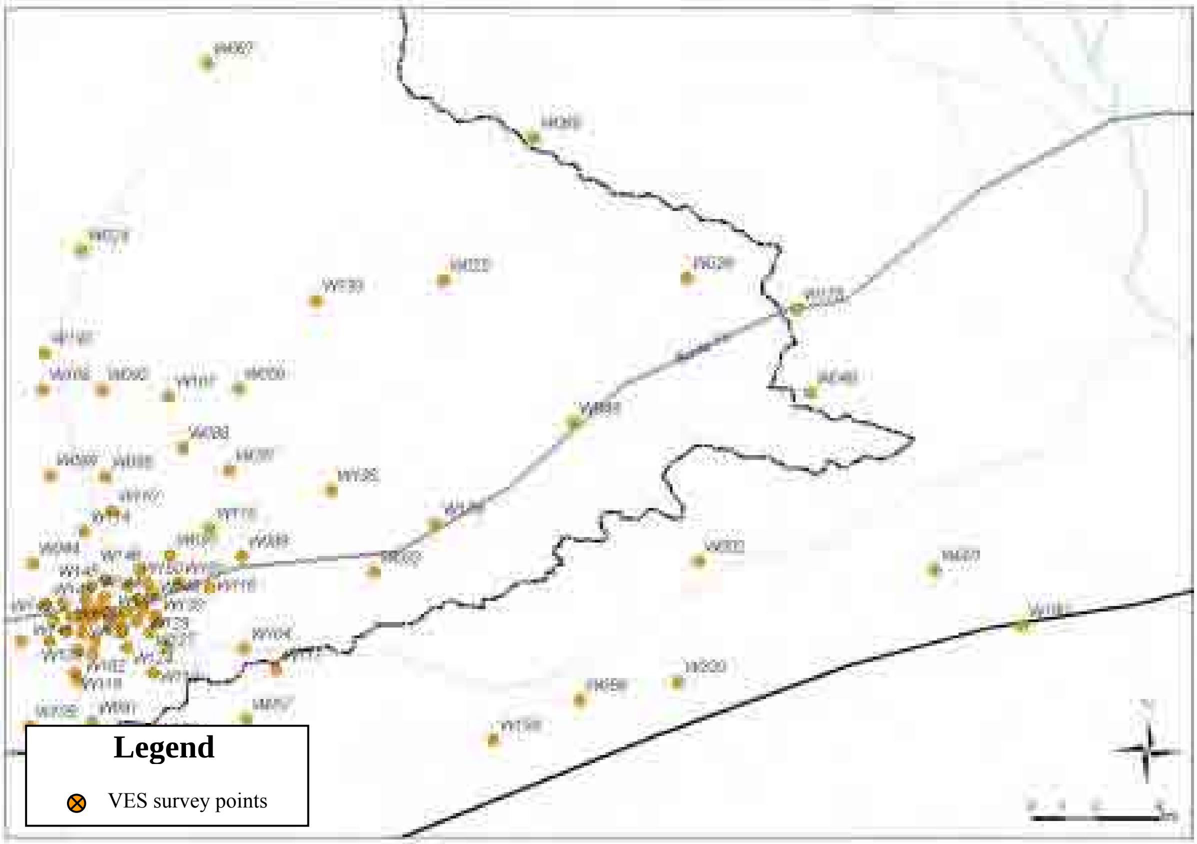


Figure 2.2.2-9 Enlarged view of VES survey points in the eastern part of Ambovombe Commune

i) Distribution of basement rock

Thickened low resistivity layer widely extends and no apparent basement rock can be figured out from the surveyed data of this area.

ii) Distribution of water bearing formation

Existence of water bearing formation is figured out at the several surveyed points. However the measured resistivity is not so high compared with other points which is described previous section. Hence the possibility of water bearing formation is not clear. Table 2.2.2-6 shows the interpreted depth and thickness of water bearing formation for surveyed points of this area.

Table 2.2.2-6 Interpreted depth and thickness of water bearing formation

Surveyed Points	Elevation (m)	Elevation of the layer(m)	Depth of the layer (m)	Thickness (m)
W048	289	271～129	18～160	142
W049	247	207～117	40～130	90
W026	283	233～143	50～140	90

At the surveyed point W066, rather high resistivity layer is interpreted at the deep part. However due to no clear trend of the measured data as usual basement rock, this formation is not considered as basement rock at this moment. At the surveyed point W025, low resistivity layer, 30 (ohm-m) exists up to the deep part.

d) Coastal area

Figure 2.2.2-10 shows enlarged view of the location of VES surveyed points in the coastal area.

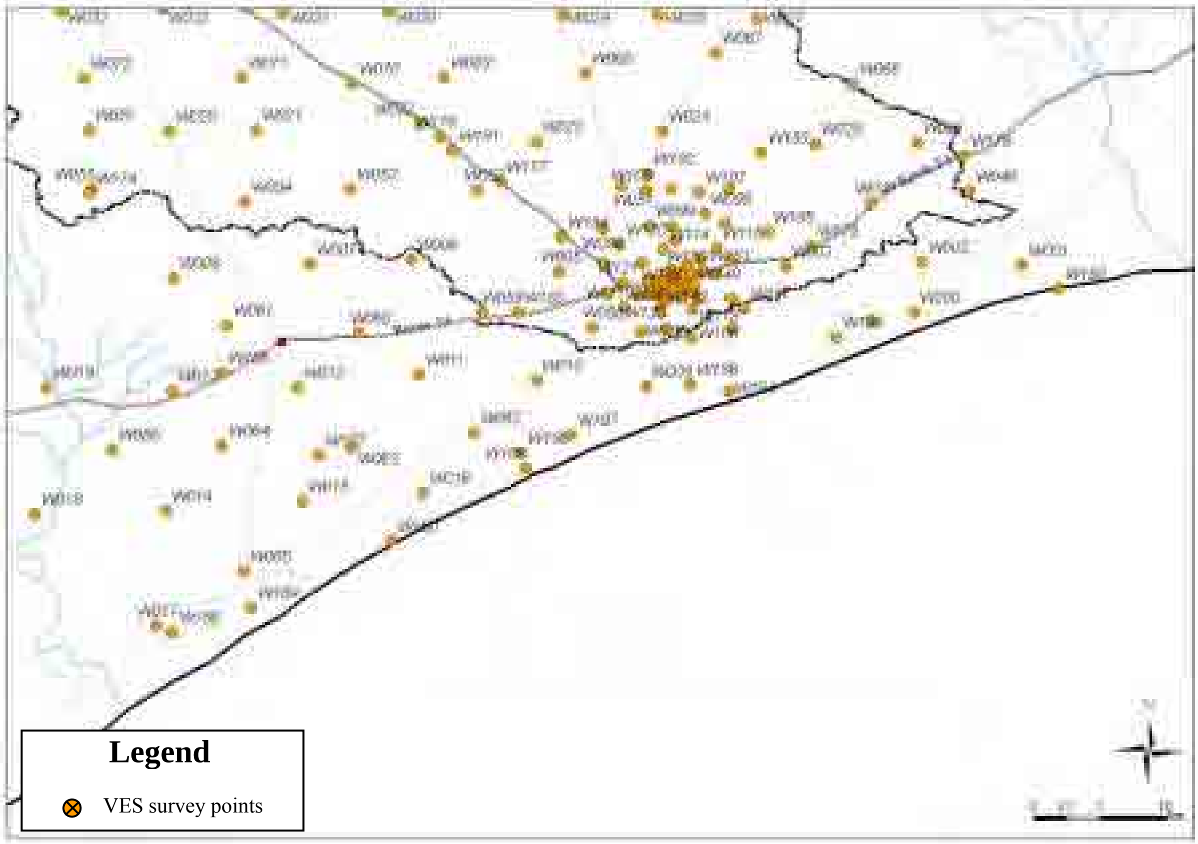


Figure 2.2.2-10 Enlarged view of VES survey points in the coastal area

Low resistivity layer which exists under the surface layer is interpreted as sandstone. Under this sandstone, measured resistivity suddenly change. This change may caused by the layer which contains sea water or the existence of other geological formation. Table 2.2.2-7 shows the interpreted elevation of low resistivity layer for surveyed points of this area.

Table 2.2.2-7 Interpreted elevation of low resistivity layer

Surveyed Points	Elevation (m)	Elevation of the layer with low resistivity (m)	Depth to the layer with low resistivity (m)
W001	200	70	130
W056	155	35	120
W009	158	8	150
W062	146	36	110
W017	126	90	36

At the survey point W002, the layer below the surface layer has rather high resistivity, 200 (ohm-m). The layer is interpreted as sandstone or sand-gravel layer which distributes in the eastern part of the Urban Ambovombe. At the survey point W065, low resistivity layer, less than 100 (ohm-m), distributes up to deep part.

e) Central part of the Ambovombe Basin

Figure 2.2.2-11 shows enlarged view of the location of VES surveyed points in the central part of the Ambovombe Basin.

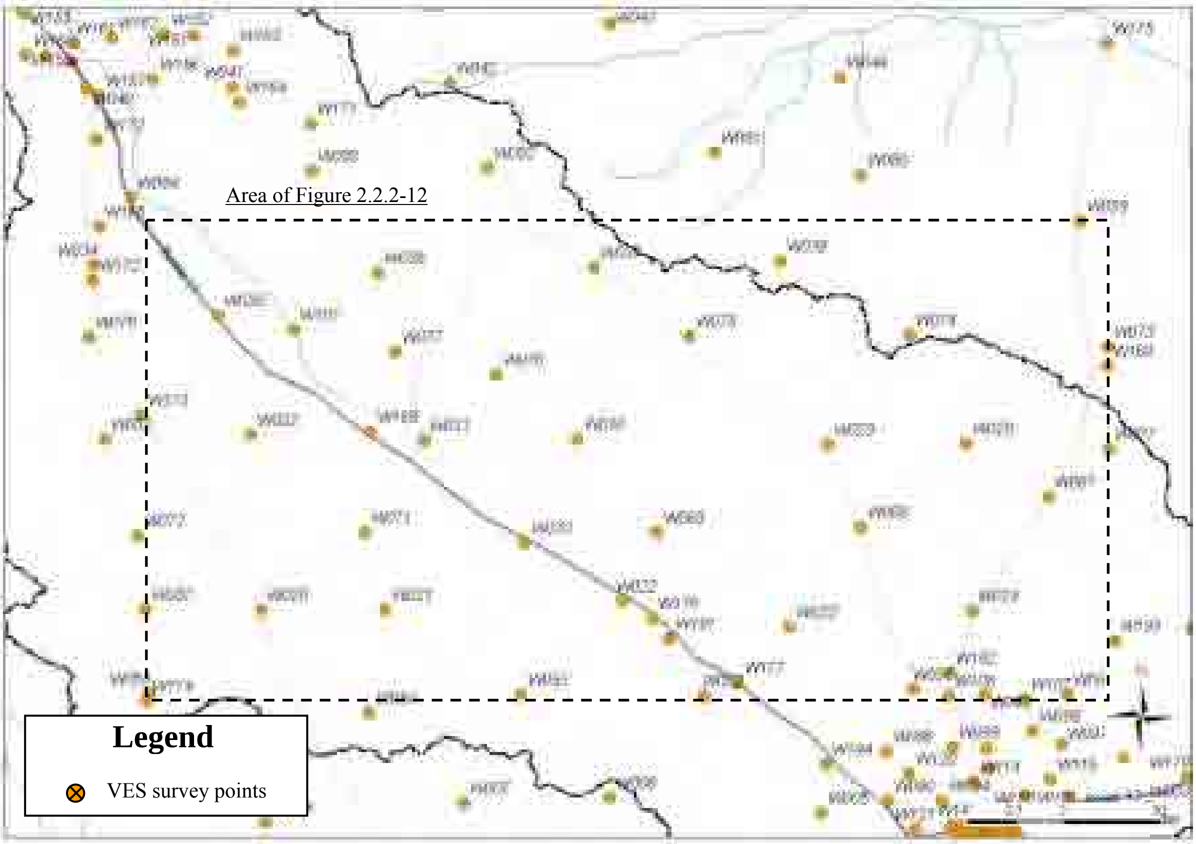


Figure 2.2.2-11 Enlarged view of VES survey points in the central part of the Ambovombe Basin

i) Distribution of basement rock

Due to the existence of thickened low resistivity layer, distribution of basement rock of this area is not clear. Table 2.2.2-8 shows the interpreted elevation of basement rock for surveyed points of this area.

Table 2.2.2-8 Interpreted elevation of basement rock

Surveyed Points	Elevation (m)	Elevation of the layer (m)	Depth to the top of the layer(m)
W023	124	90	34
W027	238	210	28
W030	150	86	64
W039	119	38	81
W055	197	108	89
W069	139	97	42
W070	152	47	105
W071	195	96	99
W072	200	147	53
W075	171	95	76

At the surveyed point W054, existence of basement rock formation is figured out at the deep part. However, due to no strong data to support the existence of rock formation at this point, W054 is excluded to list up the Table 2.2.2-8.

Contour map of the depth to the top of interpreted basement rock is shown in the Figure 2.2.2-12. The area of this contour map is shown in the Figure 2.2.2-11.

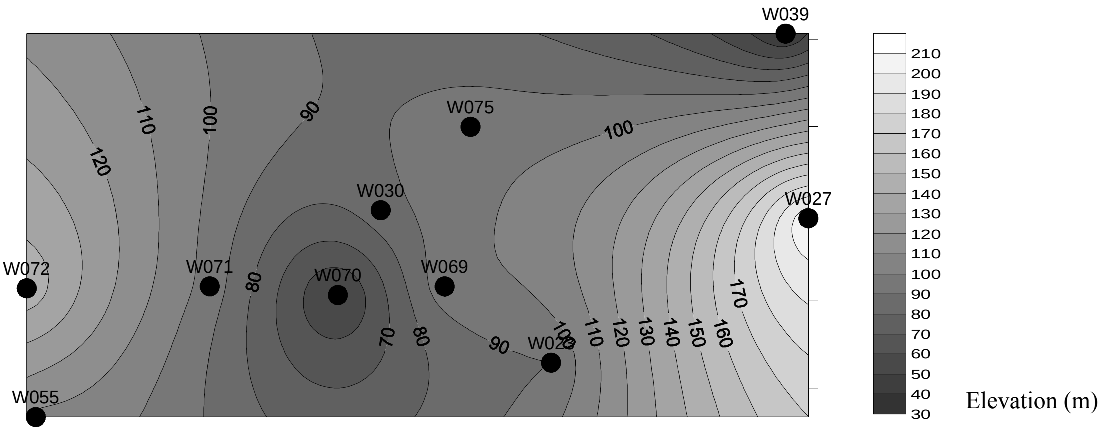


Figure 2.2.2-12 Contour map of the top elevation of basement rock

ii) Distribution of water bearing formation

Existence of water bearing formation is not figured out in this area. At the surveyed points W020, W021, W022, W052 and W053, existence of thickened muddy sediments is interpreted.

f) Northern part of the Ambovombe Basin

Figure 2.2.2-13 shows enlarged view of the location of VES surveyed points in the northern part of the Ambovombe Basin.

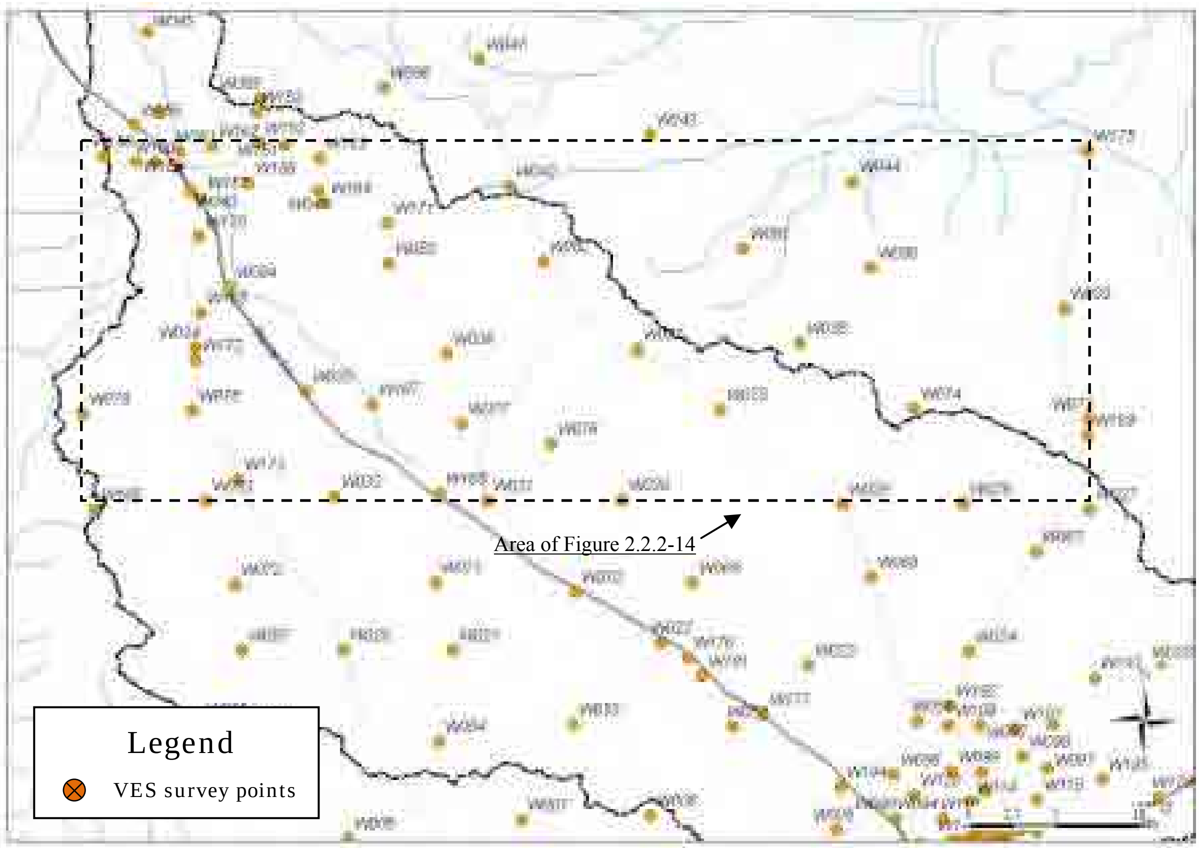


Figure 2.2.2-13Enlarged view of VES survey points in the northern part of the Ambovombe Basin

i) Distribution of basement rock

Table 2.2.2-9 shows the interpreted elevation of basement rock for surveyed points of this area.

Table 2.2.2-9 Interpreted elevation of basement rock

Surveyed Points	Elevation (m)	Elevation of the layer (m)	Depth to the top of the layer(m)
W032	186	126	60
W033	221	177	44
W034	242	232	10
W035	200	147	53
W036	192	133	59
W037	168	112	56
W038	168	113	55
W042	207	193	14
W043	174	153	21
W044	110	50	60
W076	162	101	61
W077	178	78	100
W078	220	187	33
W079	261	217	44
W080	160	146	14
W082	190	171	19
W083	220	178	42
W084	254	222	32
W163	258	221	37
W164	231	200	31
W165	240	210	30
W166	287	265	22
W170	248	227	21
W171	223	206	17
W175	77	47	30

Contour map of the dept to the top of interpreted basement layer is shown in the Figure 2.2.2-14. The area of this contour map is shown in the Figure 2.2.2-13.

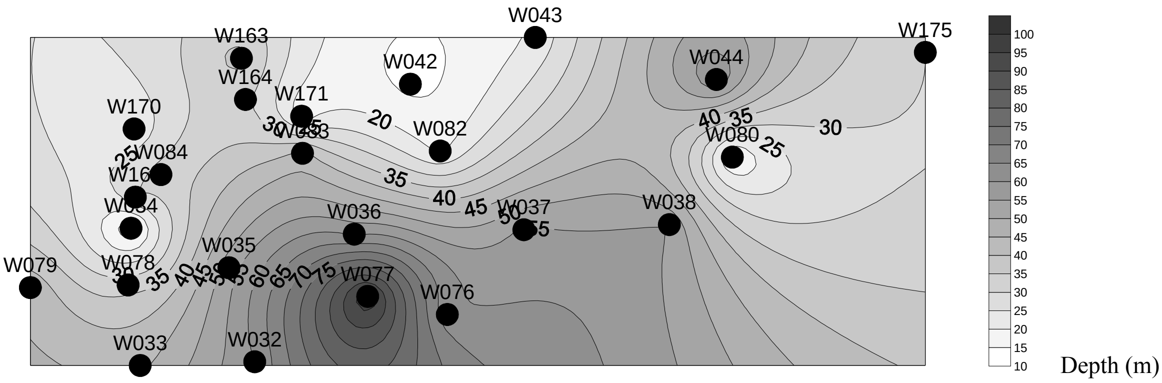


Figure 2.2.2-14 Contour map of the depth to the top of basement rock

The measured data of the surveyed points in the north western part of this area indicates almost same trend of resistivity curve. Onthe other hand, the points in the south eastern part, especially at the surveyed points, W032, W035, W036, W037, W038, W076, W077, W080 and W083, indicates different trend of resistivity curve compared with the data of north western part points.

The resistivity of basement rock formation is lower in the south eastern part and the trend of reistivity curve seems similar to the trend of data which is measured in Ambovombe.

ii) Distribution of water bearing formation

Table 2.2.2-10 shows the interpreted depth and thickness of water bearing formation for surveyed points of this area. The interpreted depth is shallow and the thickness is small. These interpreted points are scattered and there may be no continuous water bearing formation.

Table 2.2.2-10 Interpreted depth and thickness of water bearing formation

Surveyed Points	Elevation (m)	Elevation of the layer(m)	Depth of the layer (m)	Thickness (m)
W070	152	146～127	6～25	19
W074	200	192～170	8～30	22
W081	154	143～115	11～39	28

g) North end of the Ambovombe Basin

Figure 2.2.2-15 shows enlarged view of the location of VES surveyed points in the northern part of the Ambovombe Basin.

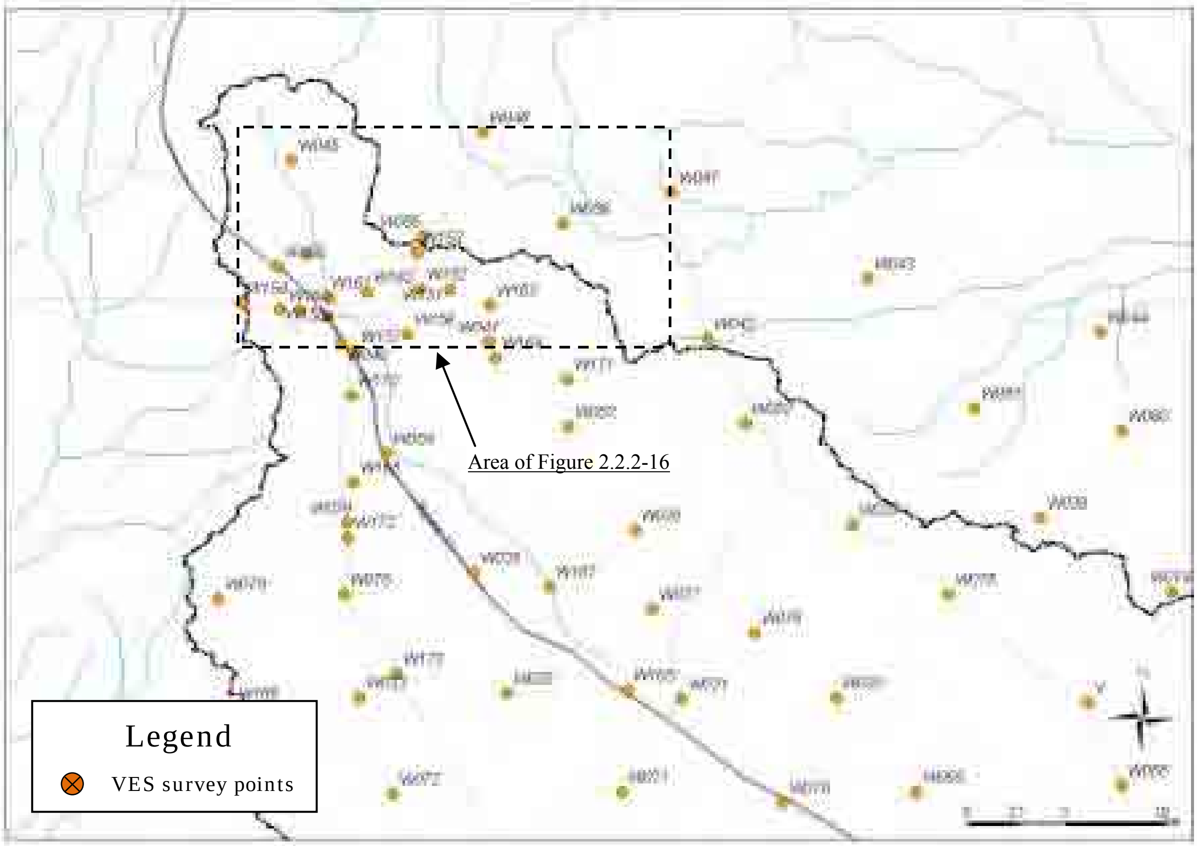


Figure 2.2.2-15Enlarged view of VES survey points in the north end of the Ambovombe Basin

Except the area with the sedimentation of sand layer, basement rock formation distributes from the depth of 20m. Resistivity of interpreted basement rock is more than 500 (ohm-m).

Table 2.2.2-11 shows the interpreted depth of basement rock for surveyed points of this area.

Table 2.2.2-11 Interpreted elevation of basement rock

Surveyed Points	Elevation (m)	Elevation of the layer (m)	Depth to the top of the layer(m)
W040	308	290	18
W041	246	231	15
W045	325	313	12
W046	258	247	11
W047	237	229.5	7.5
W085	278	273	5
W086	245	242	3
W151	270	240	30
W152	290	232	58
W153	286	241	45
W154	312	297.5	14.5
W155	319	279.3	39.7
W156	275	235	40
W157	275	240	35
W158	313	283	30
W159	308	281	27
W160	313	304	9
W161	289	280	9
W162	294	288	6

Contour map of the depth to the top of interpreted basement rock is shown in the Figure 2.2.2-16. The area of this contour map is shown in the Figure 2.2.2-15.

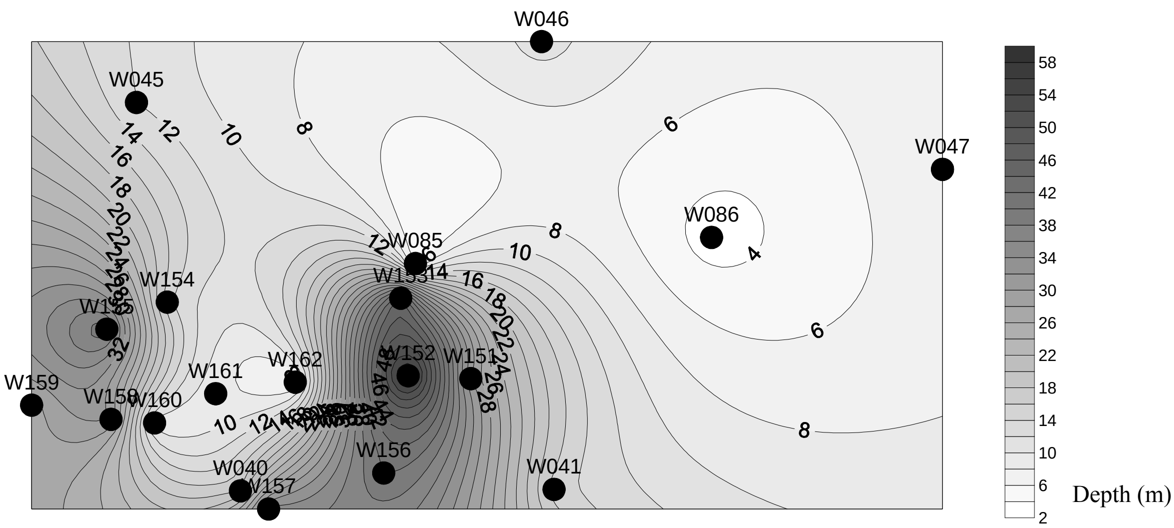


Figure 2.2.2-16 Contour map of the depth to the top of basement rock

h) Summary

The results of VES survey is summarized as following table. Figure 2.2.2-17 shows contour map of the depth to the top of interpreted basement rock for all the surveyed area.

The figure shows elevation of basement rock formation goes down from north-west to south-east. But at the south end of the Ambovombe Basin, elevation goes up to the eastern direction.

Table 2.2.2-12 Summary of results of VES survey

Area	Basement rock	Water bearing formation	Impermeable layer
Central part of the Ambovombe Commune	Existence of basement rock is interpreted. Elevation changes from 30 to 90m.	Existence of sand or gravel is interpreted. Thickness changes from 10 to 100m.	Existence of impermeable layer is interpreted. Thickness changes from 15 to 100m.
Western part of the Ambovombe Commune	Existence of basement rock is interpreted. Elevation changes from -60 to 150m.	Existence of sand or gravel is interpreted. Thickness changes from 10 to 50m.	Existence of impermeable layer is interpreted.
Eastern part of the Ambovombe Commune	*Existence of basement rock is not interpreted.*	Existence of sand or gravel is interpreted. Thickness changes from 90 to 140m.	Existence of impermeable layer is interpreted.
Coastal area	*Existence of apparent basement rock is not interpreted.*	*Existence of sand or gravel is not interpreted.*	*Existence of impermeable layer is not interpreted.*
Central part of the Ambovombe Basin	Existence of basement rock is interpreted. Elevation changes from 30 to 200m.	*Existence of sand or gravel is not interpreted.*	*Existence of impermeable layer is not interpreted.* *Thickened muddy layer is interpreted.*
Northern part of the Ambovombe Basin	Existence of basement rock is interpreted. Elevation changes from 50 to 250m.	Existence of sand or gravel is interpreted at a few surveyed points.	*Existence of impermeable layer is not interpreted.*
North end of the Ambovombe Basin	Existence of basement rock is interpreted. Elevation changes from 200 to 300m.	*Existence of sand or gravel is not interpreted.*	*Existence of impermeable layer is not interpreted.*

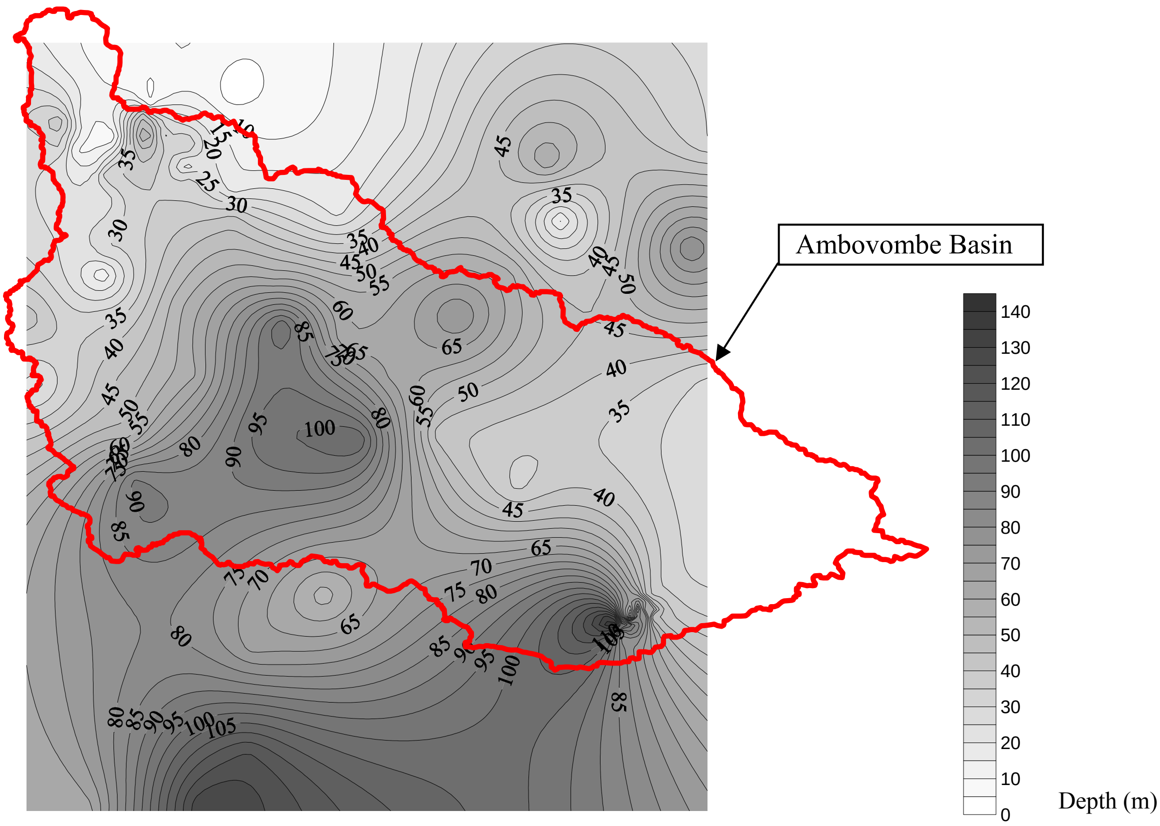


Figure 2.2.2-17 Contour map of the depth to the top of basement rock

2.2.3 IP Survey

(1) Methodology

This method measures the chargeability of subsurface layer. When electric potential is applied to subsurface layer and is switched off afterwards, discharge potential is observed after a few moments. This phenomenon is called as (time domain) induced polarization phenomenon and discharge potential changes depend on the physical properties of the subsurface layer. Chargeability is applied to express the difference of discharge potential. It is represented by the ratio of applied electric potential (primary electric potential) and discharge potential (secondary electric potential).

Usually clayey material exists at weathered or fractured subsurface zone, considered as water bearing formation, and clayey formation indicates high chargeability compared with sandy formation. Therefore IP method is effective to find such weathered or fractured formation. Figure 2.2.3-1 shows the concept of (time domain) induced polarization phenomenon.

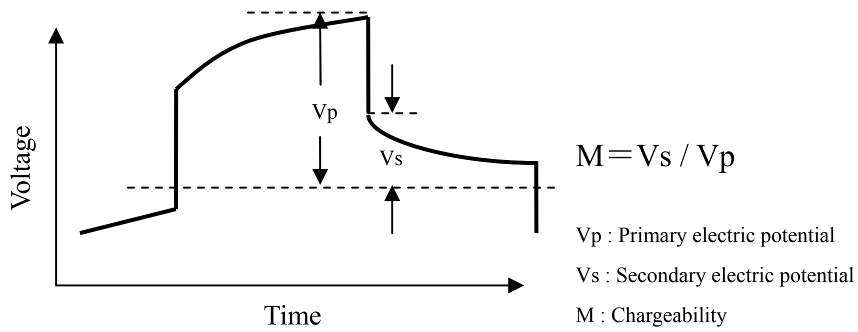


Figure 2.2.3-1 Concept of time domain IP phenomenon

Figure 2.2.3-2 shows typical arrangement of IP survey and Table 2.2.3-1 shows list of equipment which are used for this survey.

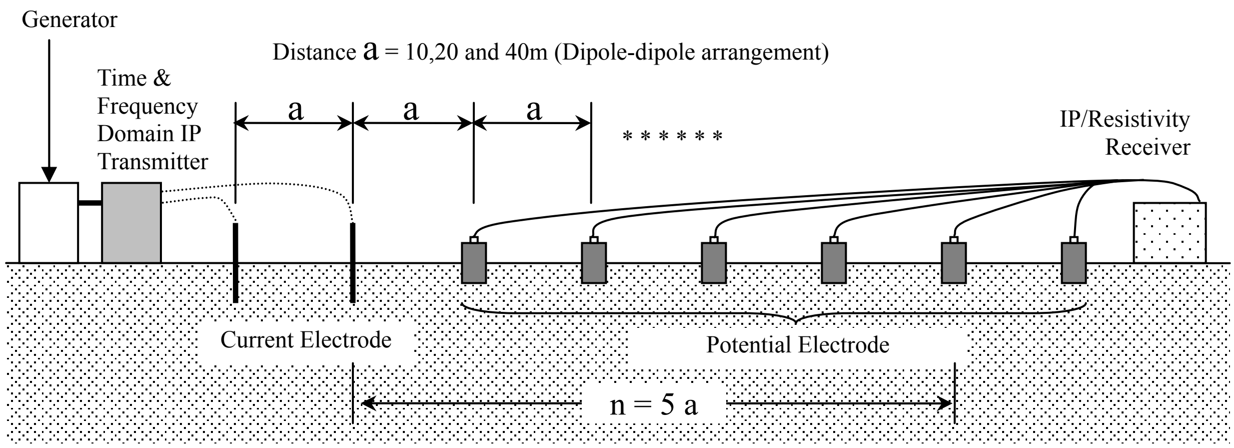


Figure 2.2.3-2 Typical Arrangement of IP survey

Table 2.2.3-1 List of Equipment for IP survey

Equipment	Type	Product	Specification	Quantity
IP/Resistivity Receiver	IPR-12	Scintrex	Sensitivity : 10μV Input Impedance : 16MΩ Range : 0〜300mV/V	1
Time & Frequency Domain IP Transmitter	VIP 3000	IRIS	Max. voltage : 3000VA Min. voltage : 3000V(MAX) Output currency : 5A(MAX)	1
Generator	FB 2200	HONDA	Max. output : 1.9kVA	1
Potential electrode			Nonpolarizable electrode（Pb-NaPb）	10
Current electrode			Steel stick 25mm dia. 90cm long	8
Electric cable			1.25mm dia.	700m

The IP receiver (IPR-12) can measure not only chargeability but also resistivity of subsurface layer at the same time. This survey is introduced to understand distribution of weathered or fractured zone within the study area. The exploration depth is set to 150m.

(2) Surveyed points

Total of eighteen (18) points were selected within the study area. Figure 2.2.3-3 shows location map of surveyed point. The length of traverse line for one surveyed point is set to 320 m long.

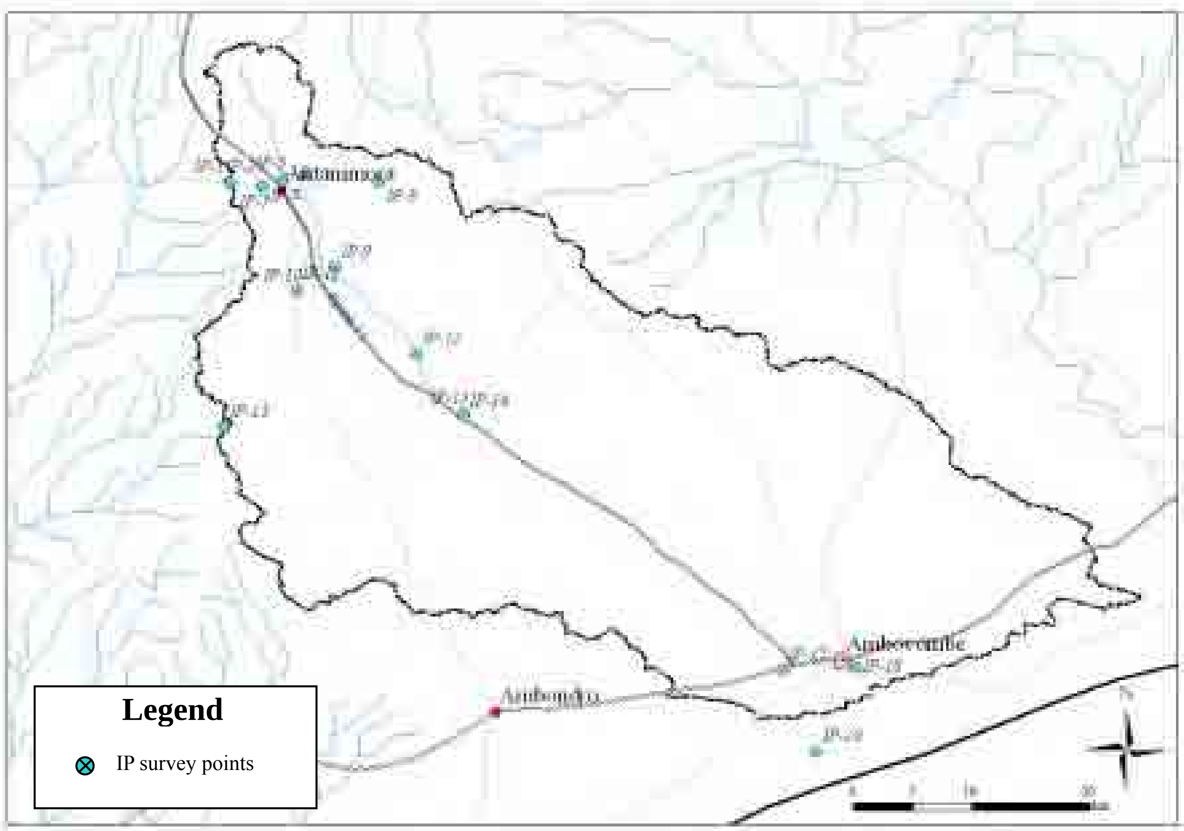


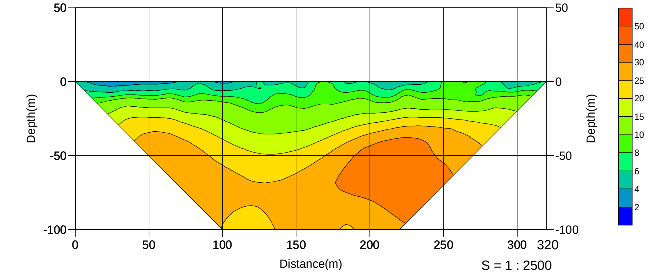
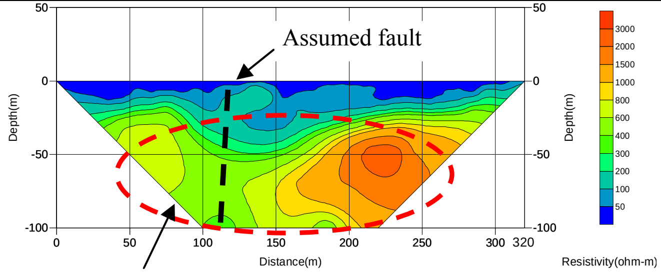
Figure 2.2.3-3 Location Map of IP Survey Points

(3) Interpretation for the measurement data

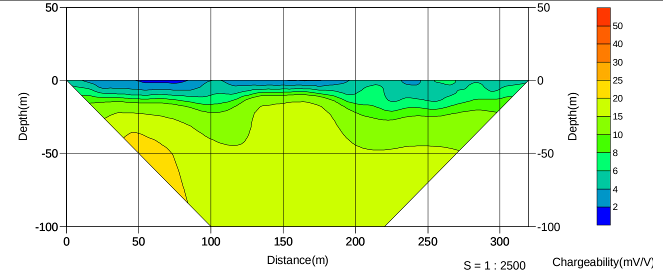
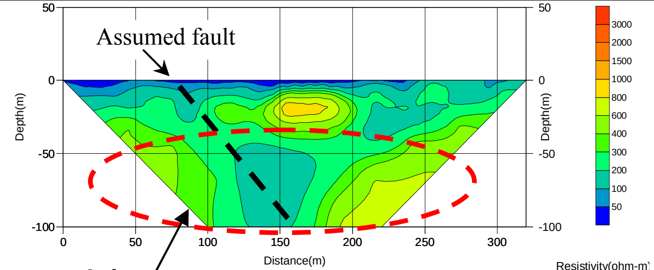
Measured chargeability and resistivity is processed and represented by isopotential section map. Table 2.2.3-2 shows result of interpretation for all the measured points.

Table 2.2.3-2 Result of interpretation for IP survey

IP-1 (Laliamena)

Cross Section		Interpretation
 Chargeability	 Resistivity	In the upper part, low chargeability value is measured. On the other hand, in the deep part, high chargeability value, more than 30mv/v, is measured. Usually rhyolite indicate such a high chargeability value. However there is no evidence for the existence of rhyolite. Up to the depth of 15m, low resistivity value, less than 100 (ohm-m) is measured. In the deeper part, high resistivity value, 300 (ohm-m), is measured. This high value zone can be interpreted as hard rock formation. In the lower right zone, due to vertical distribution of resistivity, there is possibility of fault zone.

IP-2 (Laliamena)

Cross Section		Interpretation
 Chargeability	 Resistivity	The traverse line is located parallelly 75m apart from IP-1 line. Basically trend of chargeability and resistivity value indicate almost same as the result of IP-1 line. In the deep part, vertical distribution of resistivity is also measured. This part is interpreted as fault zone which may continue from the area of IP-1 line.

IP-3 (Andaboly)

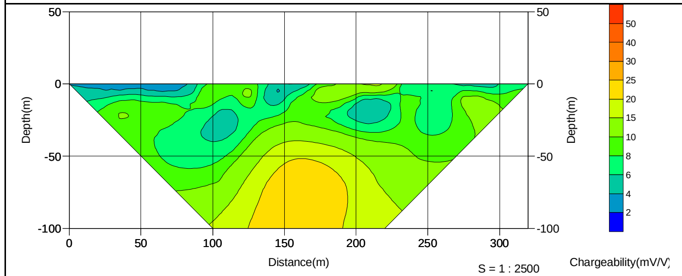
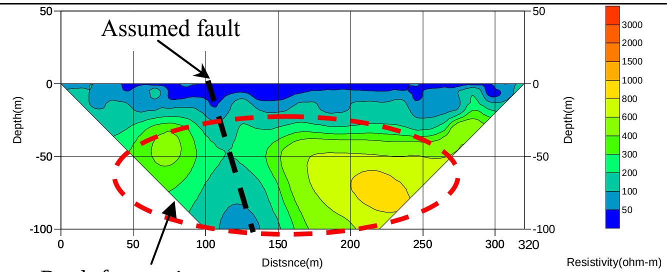
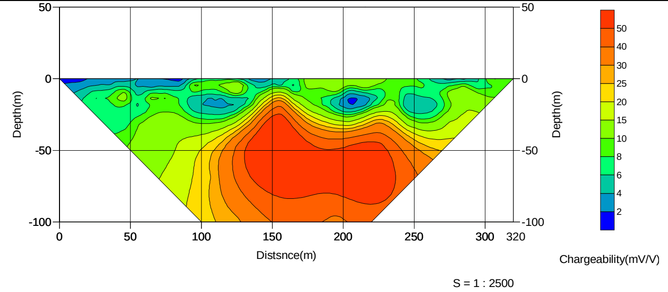
Cross Section		Interpretation
 Chargeability	 Resistivity	Trend of resistivity value indicate almost same as the result of IP-1 and IP-2 line. Trend of chargeability value indicate more complicated distribution compared with the result of IP-1 and IP-2. This trend is interpreted as strongly metamorphosed zone. In the deep part, vertical distribution of resistivity is also measured. This part is interpreted as fault zone.

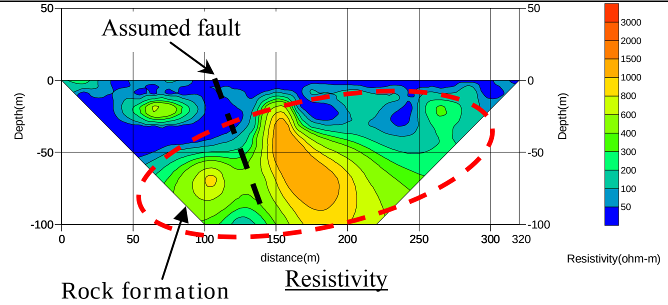
Table 2.2.3-2 Result of interpretation for IP survey (continued)

IP-4 (Andaboly)

Cross Section



Chargeability



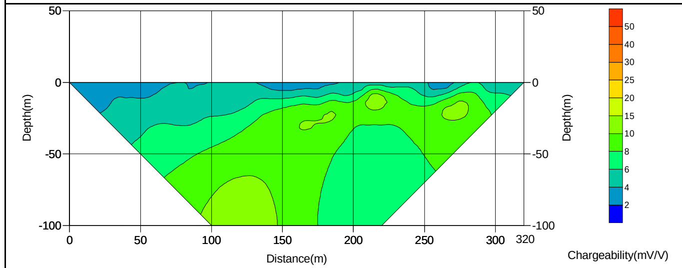
Resistivity

Interpretation

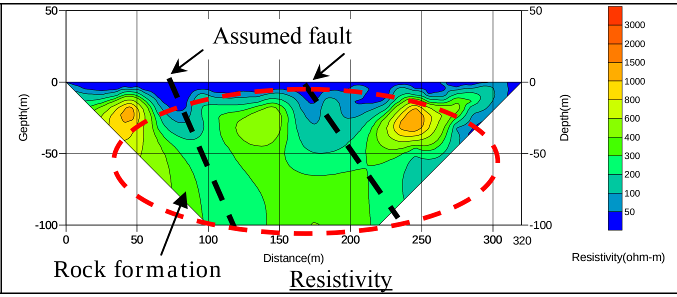
The traverse line is located parallelly 70m apart from IP-3 line.
In the upper part of left side of resistivity map, low resistivity zone is measured.
The trend of vertical distribution of resistivity may not be seen clearly.

IP-5 (Antanimora)

Cross Section



Chargeability



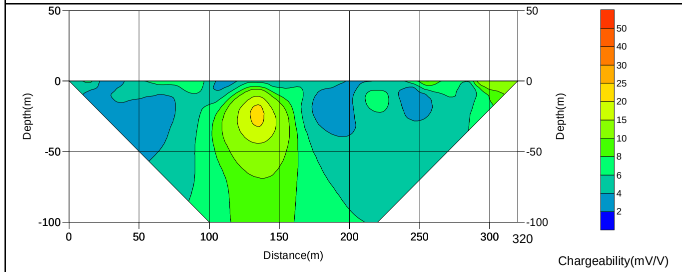
Resistivity

Interpretation

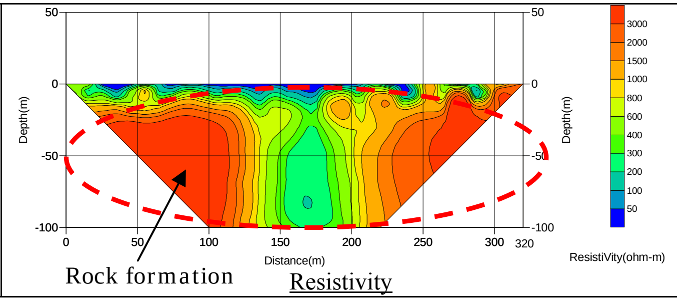
This point is located close to the center of the city.
In the upper part, from 50 to 100m of distance, and in the deeper part, from 50 to 150m of distance, the trend of vertical distribution of resistivity is measured clearly. This part is interpreted as fault zone.

IP-6 (Ankilyfaly)

Cross Section



Chargeability



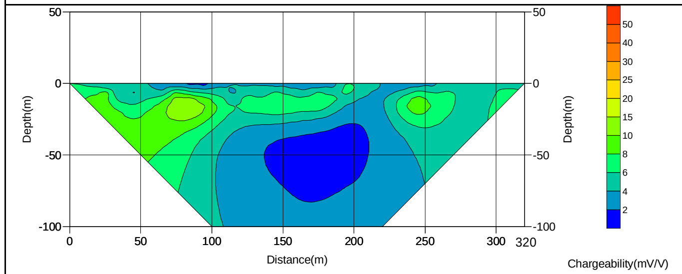
Resistivity

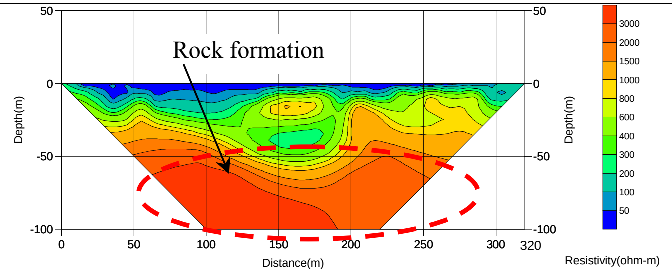
Interpretation

The traverse line is passing through the point beside the well U040137.
Measured chargeability seems to be influenced by existence of the well.
Surface low resistivity layer is very thin and deeper part is interpreted as basement rock.
The trend of vertical distribution of resistivity is seen at the center of traverse line. This trend may be influenced by fault zone.

Table 2.2.3-2 Result of interpretation for IP survey (continued)

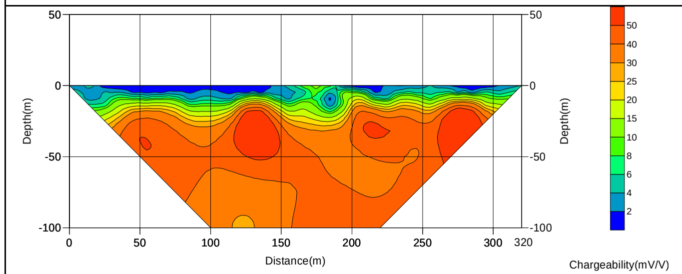
IP-7 (Ankilyfaly)

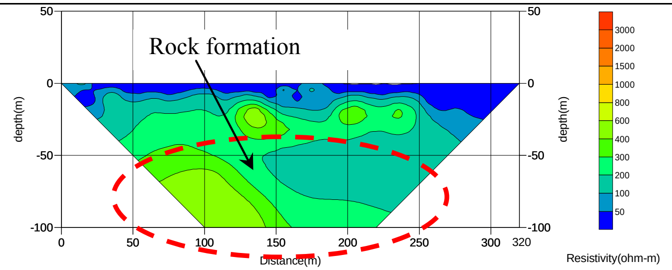
<table>
<tr><td colspan="2">Cross Section</td><td>Interpretation</td></tr>
<tr><td>

<u>Chargeability</u></td><td>

<u>Resistivity</u></td><td>Low resistivity layer is thin and the part deeper than 10m is interpreted as rock formation.
Resistivity in the central part indicate more complicated trend. This may caused by existence of weathered layer.</td></tr>
</table>

IP-8 (Analamaiky-Andoby)

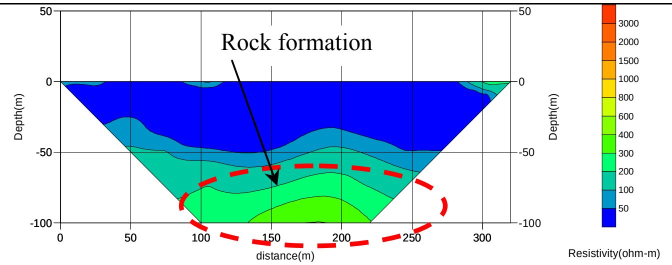
<table>
<tr><td colspan="2">Cross Section</td><td>Interpretation</td></tr>
<tr><td>

<u>Chargeability</u></td><td>

<u>Resistivity</u></td><td>Low resistivity layer is thin and the part deeper than 10m is interpreted as rock formation.
Resistivity in the upper part of right side is lower than the left side. This may caused by existence of fracture zone.</td></tr>
</table>

IP-9 (Bemanga-Marolava)

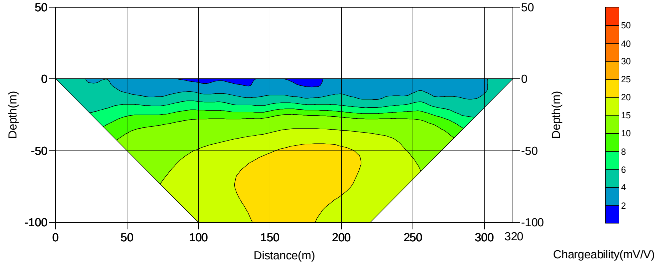
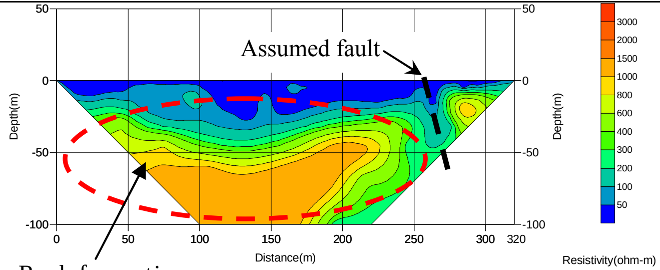
<table>
<tr><td colspan="2">Cross Section</td><td>Interpretation</td></tr>
<tr><td>Chargeability could not be measured

<u>Chargeability</u></td><td>

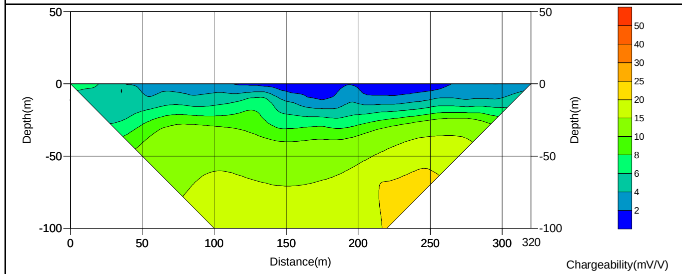
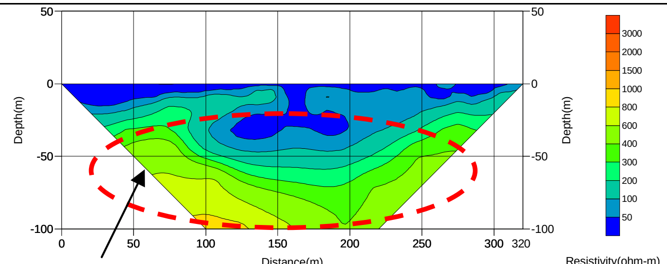
<u>Resistivity</u></td><td>The trend of chargeability and resistivity value indicate parallel distribution.
Resistivity value is less than 100 (ohm-m) up to the depth of 50m and become higher, 200 (ohm-m), in the deeper part.
This higher resistivity layer is interpreted as rock formation.</td></tr>
</table>

Table 2.2.3-2 Result of interpretation for IP survey (continued)

IP-10 (Marolava)

Cross Section		Interpretation
 Chargeability	 Resistivity	Low resistivity zone, 100(ohm-m), is measured in the upper part. This layer becomes thicker in the center part. The trend of vertical distribution of resistivity is measured in the right part. This zone is interpreted as fracture zone.

IP-11 (Marolova)

Cross Section		Interpretation
 Chargeability	 Resistivity	The traverse line is located parallelly 65m apart from IP-10 line. Low resistivity zone, 100 (ohm-m), is measured in the upper part. As well as IP-10 line, this layer becomes thicker in the center part. However vertical distribution of resistivity is not measured.

IP-12 (Manave)

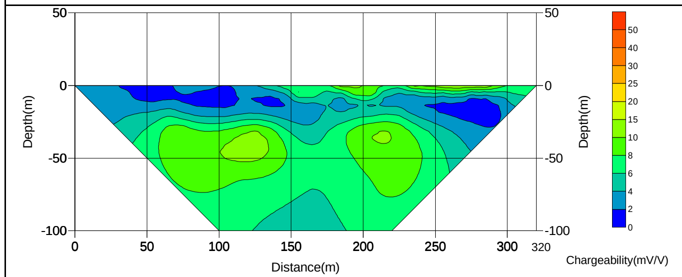
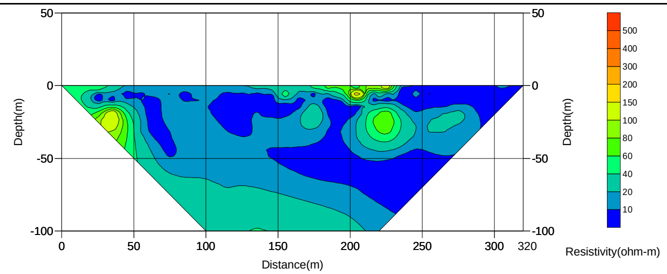
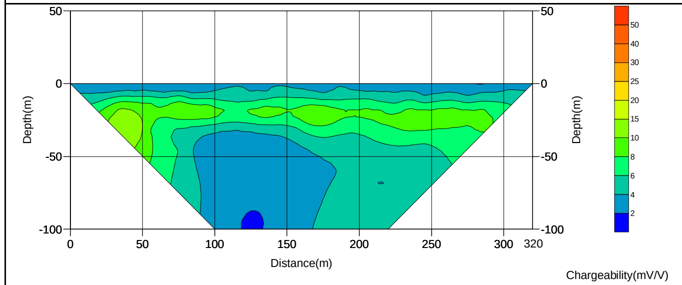
Cross Section		Interpretation
 Chargeability	 Resistivity	The traverse line is crossing the river. Low resistivity zone is measured from upper to deeper part. This layer is interpreted as muddy sediments as well as IP-13 line.

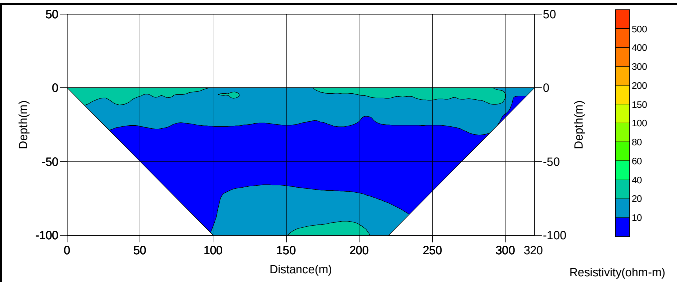
Table 2.2.3-2 Result of interpretation for IP survey (continued)

IP-13 (Sanamaro)

Cross Section



Chargeability



Resistivity

Interpretation

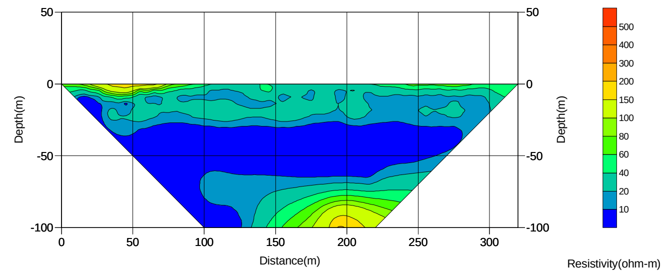
Low resistivity zone is measured from upper to deeper part.
This layer is interpreted as muddy sediments as well as IP-12 line.

IP-14 (Sanamaro)

Cross Section

Chargeability could not be measured

Chargeability



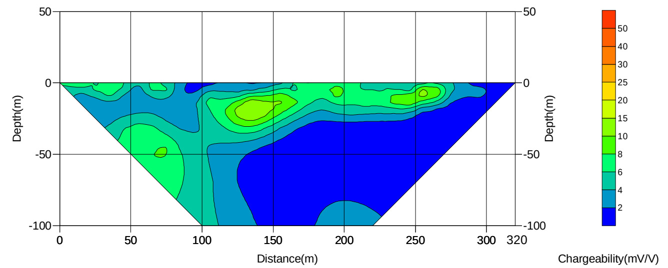
Resistivity

Interpretation

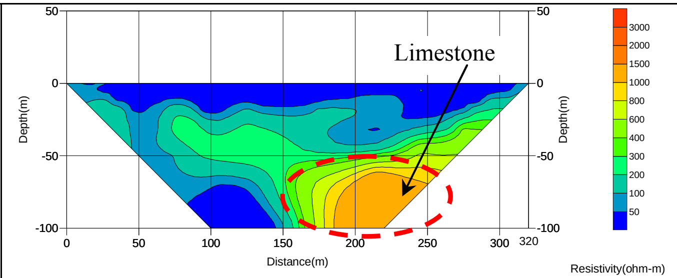
The traverse line is located parallelly 500m apart from IP-13 line.
Due to the existence of coarse sand embankment, IP survey couldn't be conducted.
Low resistivity zone, less than 50(ohm-m), is measured from upper to deeper part. This layer is interpreted as muddy sediments.

IP-15 (Androtsy)

Cross Section



Chargeability



Resistivity

Interpretation

High resistivity zone is measured in the deeper part of right side. This layer is interpreted as rock formation.
Due to low chargeability value of this part, this layer is interpreted as limestone.
The zone with high chargeability coincides with low resistivity zone. This zone is interpreted as the formation including clayey material.

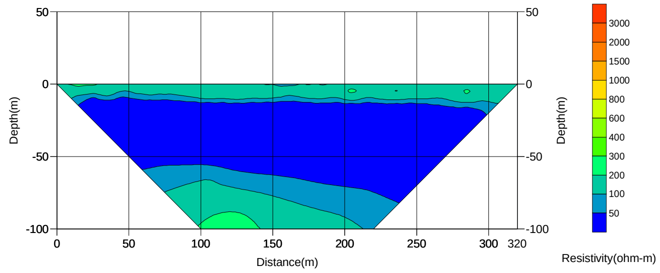
Table 2.2.3-2 Result of interpretation for IP survey (continued)

IP-16 (Ambovombe)

Cross Section

Chargeability could not be measured

Chargeability



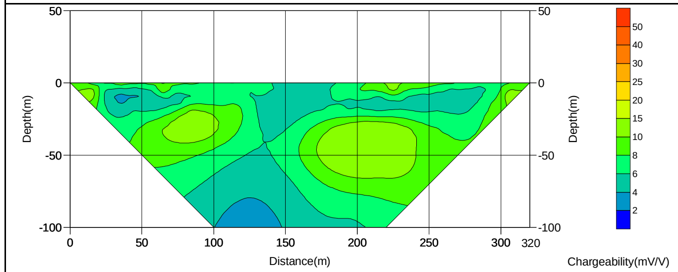
Resistivity

Interpretation

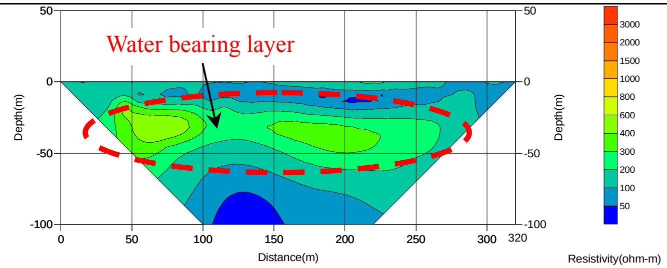
This point is selected from the representative of the area which the obtained VES survey data indicate typical trend within Urban Ambovombe area.
Due to very low resistivity value of this area, chargeability couldn't be measured.
Low resistivity zone is measured from upper to deeper part. The thickness of this layer is very large. In such a case it is difficult to interpret the resistivity of deeper part.

IP-17 (Ambovombe)

Cross Section



Chargeability



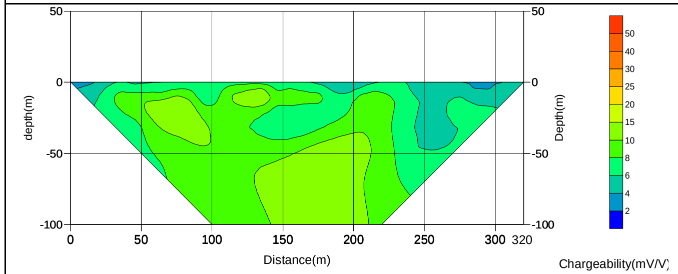
Resistivity

Interpretation

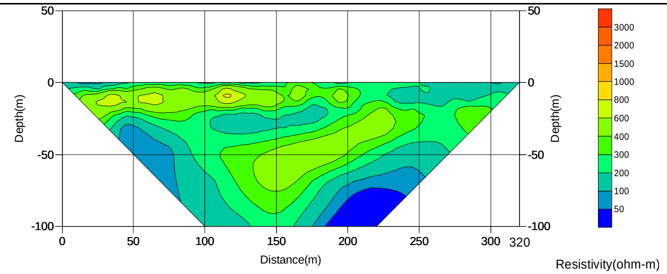
This point is located in the western part of Ambovombe basin. This point coincides with the VES surveyed point which is interpreted as the formation with water baring layer.
In the depth of 20 to 50m, high resistivity zone is measured. And low resistivity zone is measured in the deeper part.
This zone is interpreted as sand-gravel layer which can be productive aquifer.

IP-18 (Ambovombe)

Cross Section



Chargeability



Resistivity

Interpretation

This point is located in the area close to dune.
High resistivity zone is measured from upper to deeper part and low resitivity layer lies in the depth of 20 to 40m.
The more higher resistivity zone which is measured in the deeper part is interpreted as sand stone.

2.2.4 TEM Survey

(1) Methodology

This method measures resistivity of subsurface layer. When electric potential is applied to surface ground, electro-magnetic field occurs around the currency. Afterwards, when currency is switched off, trend of attenuation of generated electro-magnetic field changes depends on the resistivity of subsurface layer. If measurement period of attenuation of electro-magnetic field becomes longer, the data indicates the information of deeper subsurface layer.

This method is not affected by topography or surface structure and is sensitive to the change of resistivity.

Figure 2.2.4-1 shows typical arrangement of TEM survey and Table 2.2.4-1 shows list of equipment which are used for this survey.

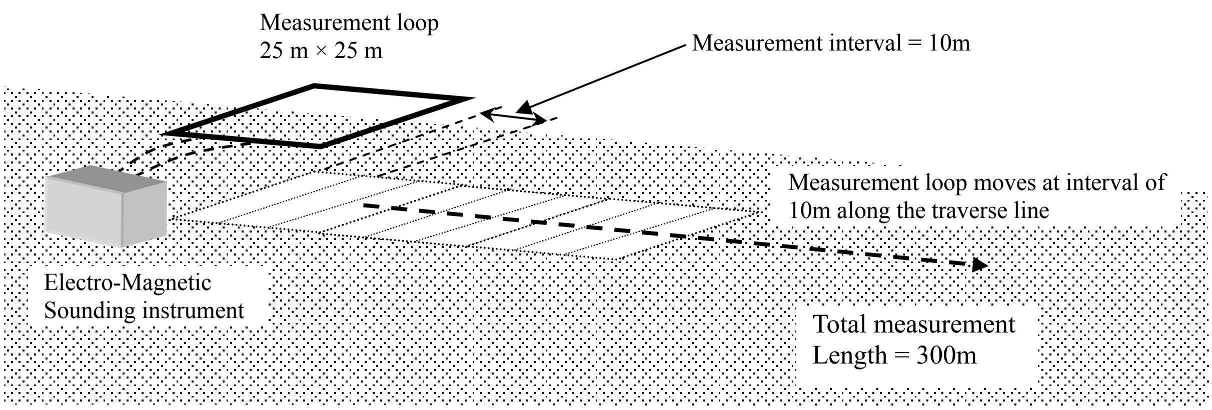


Figure 2.2.4-1 Typical Arrangement of TEM Survey

Table 2.2.4-1 List of Equipment for TEM Survey

Equipment	Type	Product	Specification		Quantity
Electro-Magnetic Sounding instrument	TEM-FAST 48HP		Out put currency	: 1 A (Max.)	1
			Loop length	: 25 m × 25 m	
			Stack time	: 2.5 min	
Battery			12 V, 12 A		1
Electric cable			0.75mm dia.		100m

Loop length is set to 25m as a basis. However, in places where limited open spaces can be secured, modification of loop length is applied. This survey is introduced to understand distribution of weathered or fractured zone within the study area. The exploration depth is set to 100m.

(2) Surveyed points

Total of thirty two (32) points were selected within the study area. Figure 2.2.4-2 shows the location map of surveyed points. The length of traverse line for one surveyed point is set to 300 m long.

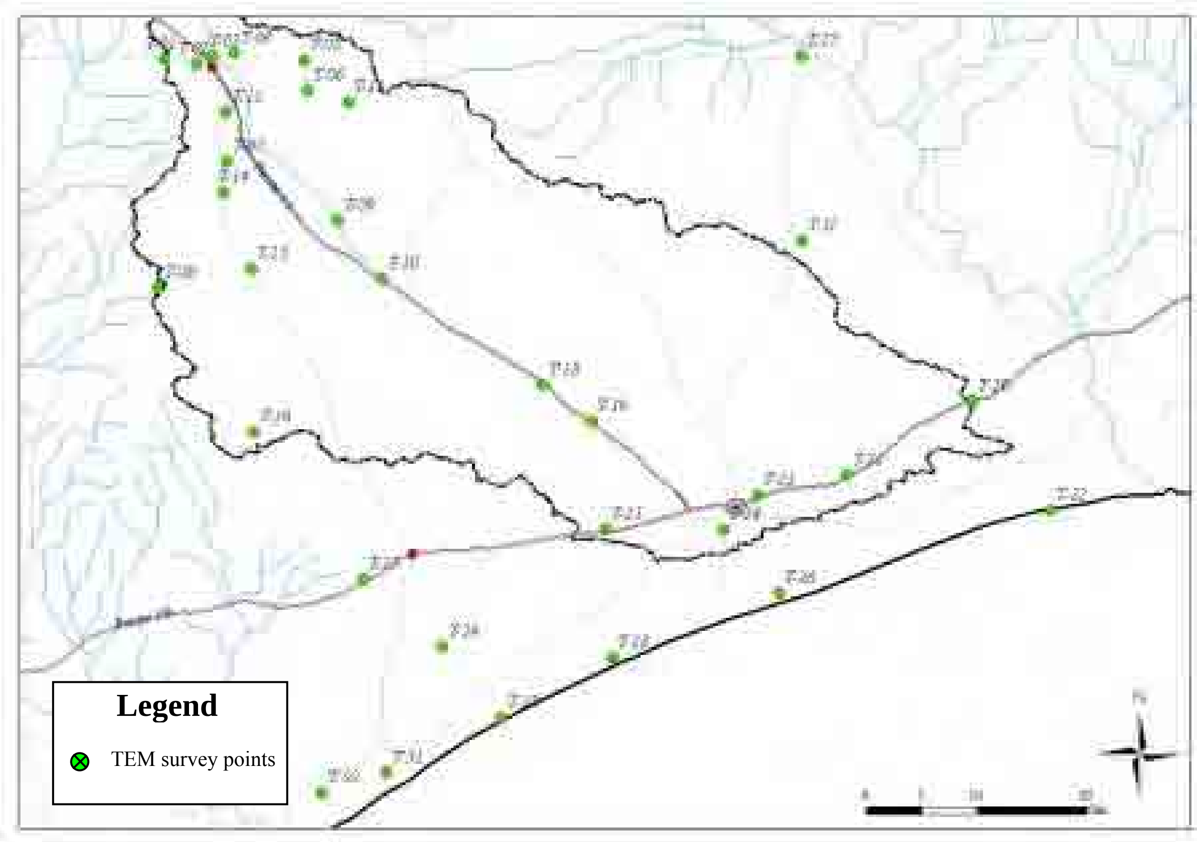


Figure 2.2.4-2 Location Map of TEM Survey Points

(3) Interpretation for the measurement data

The results of interpretation for measurement data are shown in the Table 2.2.4-2.

Table 2.2.4-2 Result of intepretation for TEM survey

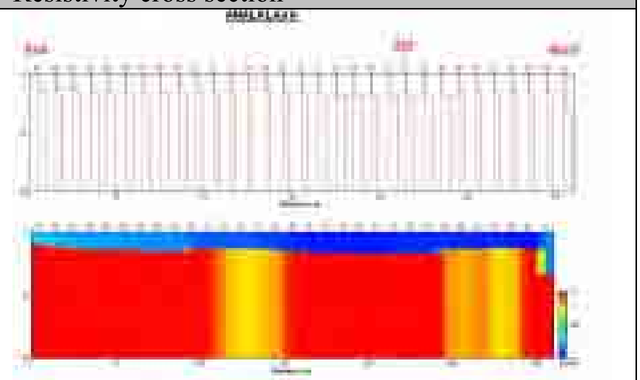
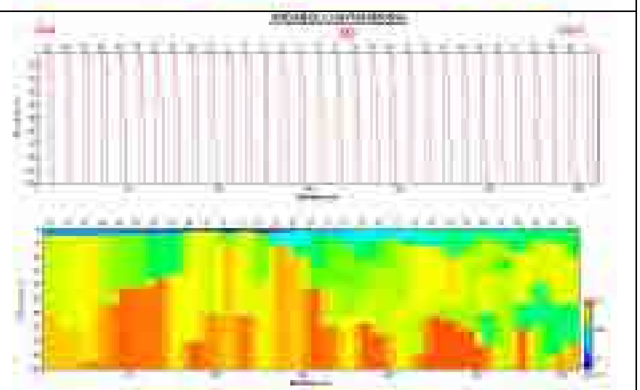
Interpretation	Resistivity cross section
T-1 (W-159) Analalava Due to polarization resistivity under 20m was measured below zero. 20m and above was analyzed. The surface layer was only 1m, and underneath lays the base rock. Because the analysis depth was shallow it cannot be clear, but the low resisitivity at 12 - 15m and 25-29m compared to the surrounding layer seems to be effects of faults.	
T-2 (W-160) Antanimora Andaboly Low resistivity layer is seen from 2m to 5m. The basement rock seem to lay below, which extends from the start point until around 9m. The low resistivity from 16 m to the end point around 60 - 70m compared to the center can be interpreted as from development of cracks.	

Table 2.2.4-2 Result of interpretation for TEM survey (continued)

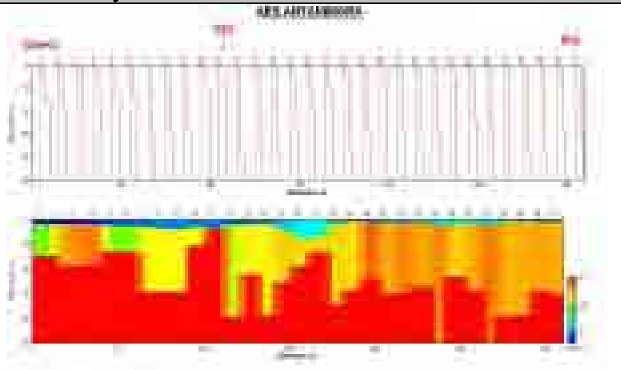
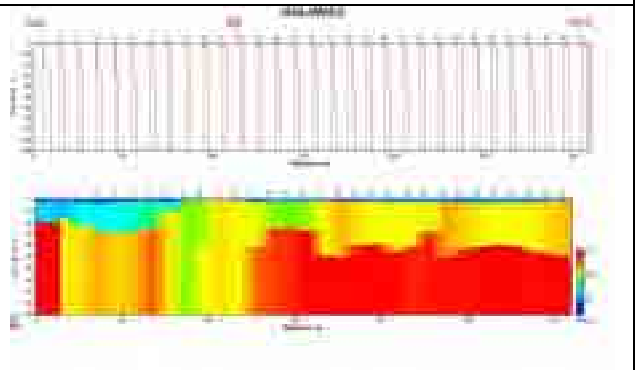
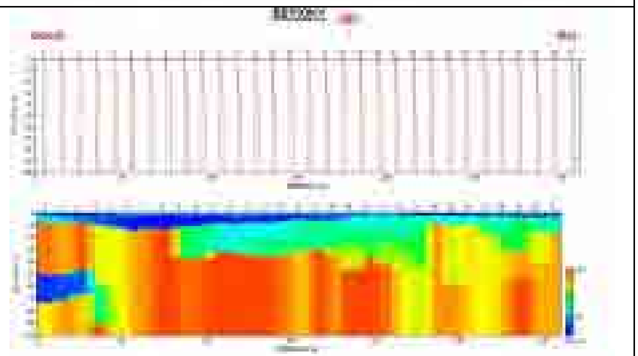
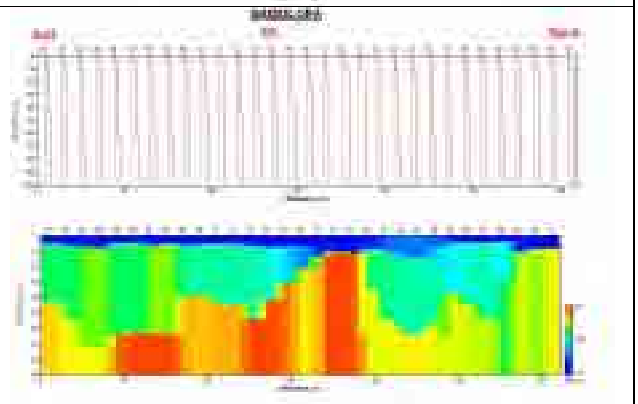
Interpretation	Resistivity cross section
T-3 (W161) AES Antanimora Loop length of 10m was applied due to limited area of the survey point. From the depth of 2 to 4m, basement rock is interpreted. Difference of resistivity may be influenced by the degree of weathering.	
T-4 (W162) Ankilifaly Due to polarization in the point, resistivity was not measured.	
T-5 (W163) Analamakika (loop length; 25m×25m) Low resistivity layer, less than 10 (ohm-m), covers the section. Thickness is estimated around 1 to 2 m deep. In the left side, under the low resistivity layer, high resistiviy layer, 100-200 (ohm-m), exists up to deeper part. In the other hands, on the right side, high resistivity layer, 100 to 300 (ohm-m), also exists under the low resistivity layer. In the middle part, no high resistivity layer can be measured. This part is interpreted as fault zone.	
T-6 (W164) Betioky Low resistivity layer, less than 10 (ohm-m), distributes from surface to the depth of 2 to 10m. Under the surface layer, basement rock distributes. Resistiviy of this rock layer is rather low compared with the measured resistivity of rock layer in the other point. Low resistivity layer which distributes in the left side is influenced by the weathered zone. Low resistivity layerof 30-50 (ohm-m), which distributes at the right side is influenced by the fault zone.	
T-7 (W165) Namolora The low resistivity layer of 50(ohm-m) is seen around 5m depth at both sides of the traverse line, and 10m at the center. At the end of both sides there observed layers of 100 to 200 (ohm-m) to about 60m, then below this layer high resitisivity layer of 500 (ohm-m) was measured. In the central area, high resistivity layer measuring 500(ohm-m) lays directly beneath the low resistivity layer at the surface. Resistivity measuring 100-200 (ohm-m) at around 280m from the start point down deep beneath is interpreted as effects of fault zone.	

Table 2.2.4-2 Result of interpretation for TEM survey (continued)

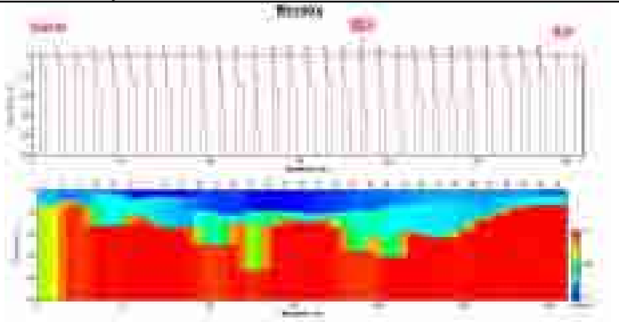
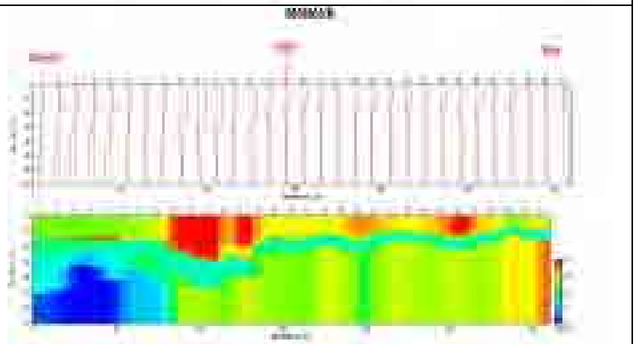
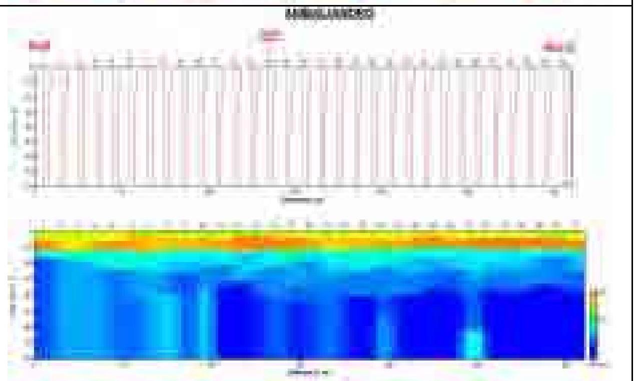
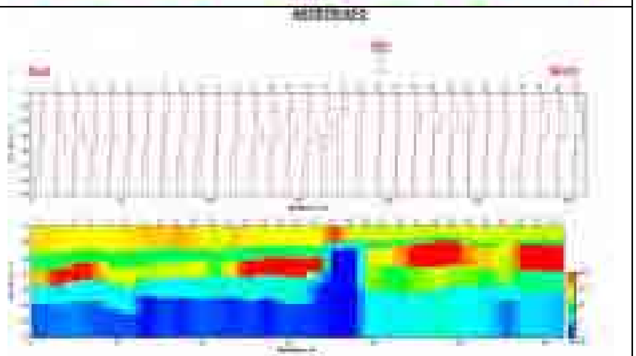
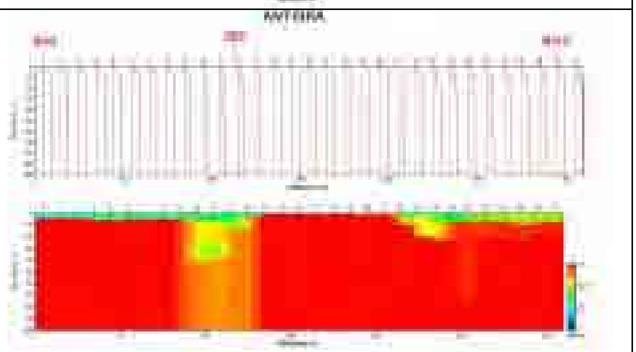
Interpretation	Resistivity cross section
T-8 (W166) Bevotsy Low resistivity layer, 10-20 (ohm-m), distributes at the surface. Thickness of the layer is larger at the center of traverse line. High resistivity layer, 100-200 (ohm-m), may be influenced by the weathered zone.	
T-9 (W167) Manave Low resistivity layer which distributes in the left side under 40m deep is interpreted as muddy sediments. Other layer is interpreted as sand sediments and high resistivity, 1,000 (ohm-m), is interpreted as boulder stone.	
T-10 (W168) Ambaliandro (loop length; 12m×12m) Low resistivity layer, less than 30 (ohm-m), exist from top to bottom. Horizontal structure is measured and no deformation zone can be seen. Resistivity changes from 20-30 (ohm-m) in the upper part to 5 (ohm-m) in the deep part.	
T-11 (W169) Antetikafo Resistivity changes from 10 to 500 (ohm-m) from the surface. At the deep part, low resistivity layer, less than 10 (ohm-m), distributes. High resistivity layer, 500 (ohm-m), is interpreted as sandy gravel layer.	
T-12 (W170) Antsira At both ends of the traverse line lays 10 - 50(ohm-m) of surface layer to 5m, and beneath this layer lays high resitivity layer measuring over 500 (ohm-m) to the deepest point. In the central area, outcrop can be seen. 9-13m from the start point has relatively low resistivity compared to the surroundings, which can be interpreted as difference of crack development or effects of fault zone.	

Table 2.2.4-2 Result of interpretation for TEM survey (continued)

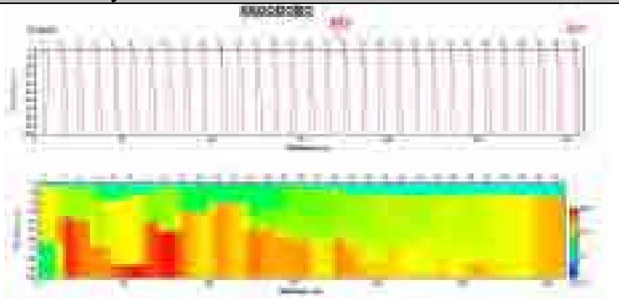
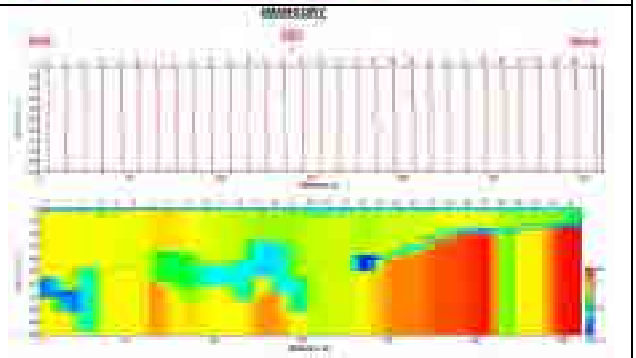
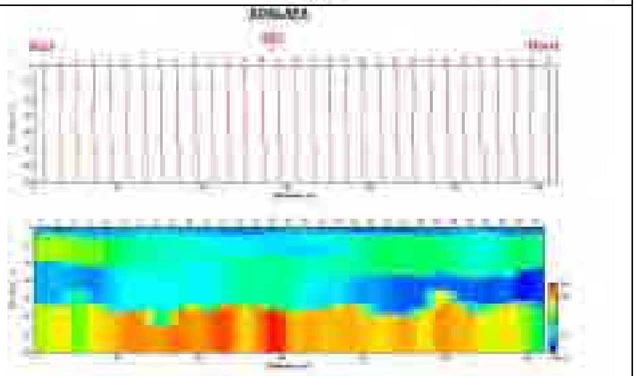
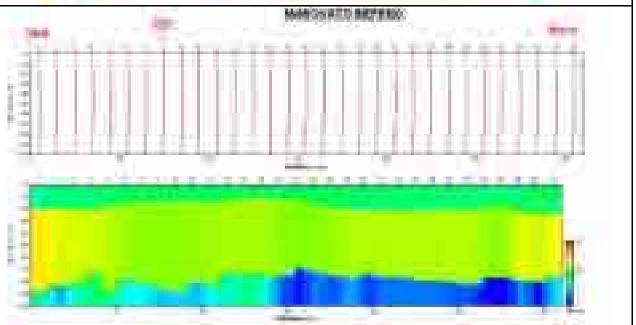
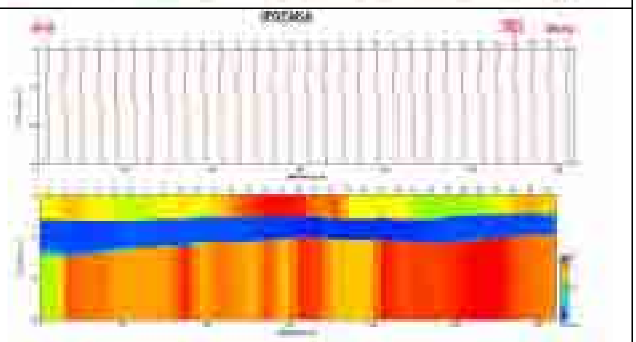
Interpretation	Resistivity cross section
T-13 (W171) Angodobo Low resistivity layer distributes as surface layer and its thickness is from 2 to 14m. Lower part is interpreted as basement rock. Central part of this layer seems highly weathered layer.	
T-14 (W172) Imangory Loop length of 12m was applied due to limited area of the survey point. At the left part, thickened muddy or sandy sediments distribute. Lower part is interpreted as basement rock and its depth is 15 to 80m.	
T-15 (W173) Soalapa Loop length of 12m was applied due to limited area of the survey point. Virtually parallel structure. Basement rock should be 40m and under.	
T-16 (W174) Marovato Befeno Parallel subsurface structure is interpreted. At the right part, low resistivity layer distributes at the depth of deeper than 80m. At the left part, rather low resistivity layer is also distributed.	
T-17 (W175) Entrée Ifotaka Very low resistivity layer, 2 (ohm-m), distribute between the surface and deeper low resistivity layer. This very low resistivity layer in interpreted as muddy sediment layer which is driven by river stream.	

Table 2.2.4-2 Result of interpretation for TEM survey (continued)

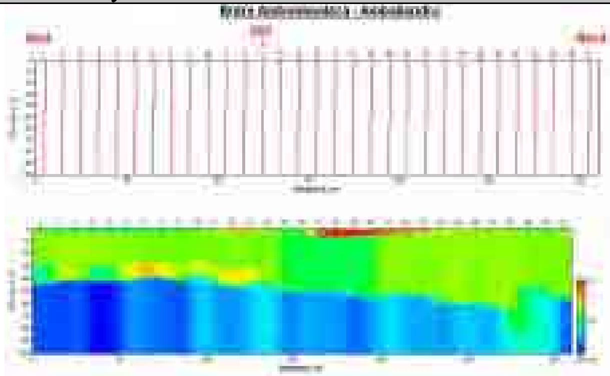
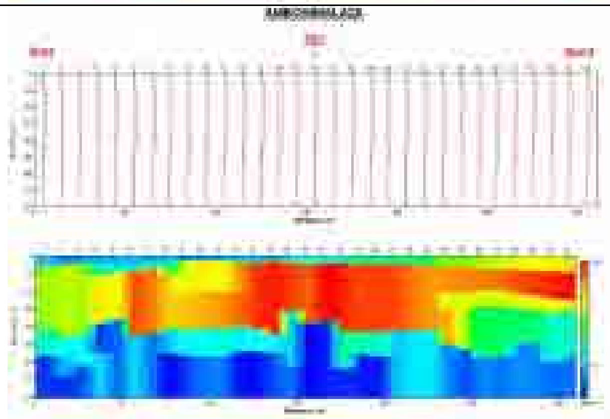
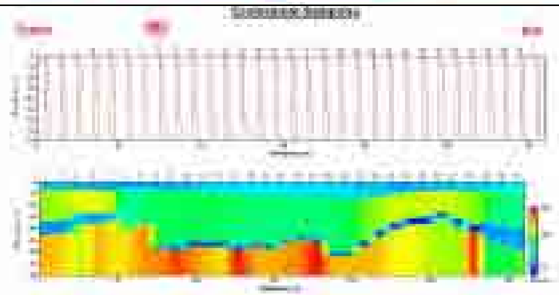
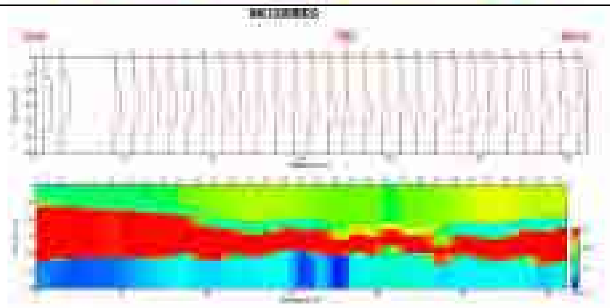
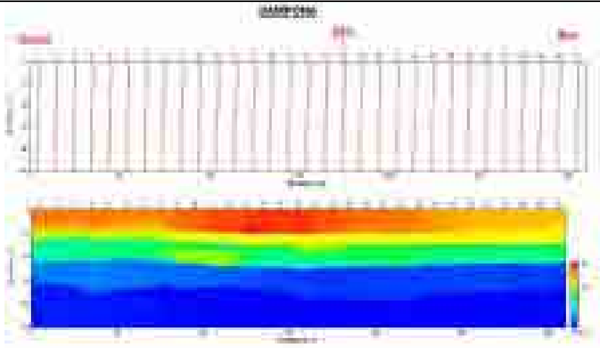
Interpretation	Resistivity cross section
T-18 (W176) Entre Ambohimalaza-Ambaliandro Whole area measures low resisitivity measuring 100(ohm-m). Pelitic sediments lay to the deep layer.	
T-19 (W177) Ambohimalaza There is a layer measuring around 100 (ohm-m) at 10-40m in depth. This can be interpreted as sand or gravel layer. Beneath this lays 10(ohm-m), which seems to be clay (aquiclude), meaning a possibility of an aquifer.	
T-20 (W178) Crois Sampona Low resistivity layer, 10 (ohm-m), distribute at the depth of 40 to 50m. The thickness of this layer is around 10m. Previously conducted VES survey results indicate possibility of aquifer layer in this point. Hence upper part of the low resistivity layer is interpreted as aquifer layer.	
T-21 (W179) Betsimeda High resitivity layer can be seen in 12-44m depth at the start point, 22-34m at the central point and 24-44m at the end point. Beneath this lays a possible clay measuring 10(ohm-m), which has high possibility of an aquifer.	
T-22 (W180) Sampona Virtually a parallel structure. The surface layer measures 40 (ohm-m), and resitivity gradually lowers as it goes deep. The layer under 22m measuring 5(ohm-m) and lower is probably effects of saline water.	

Table 2.2.4-2 Result of interpretation for TEM survey (continued)

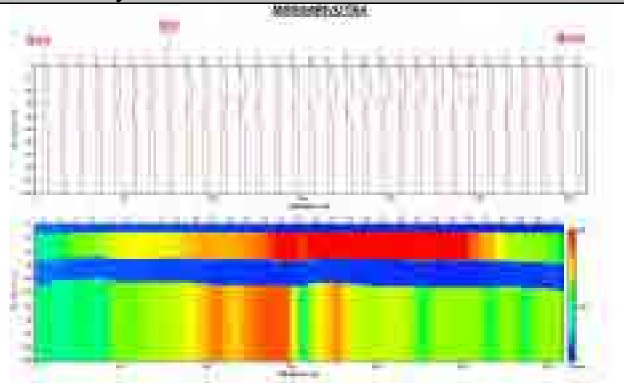
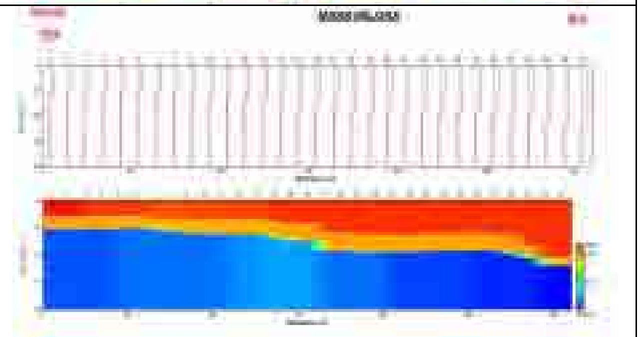
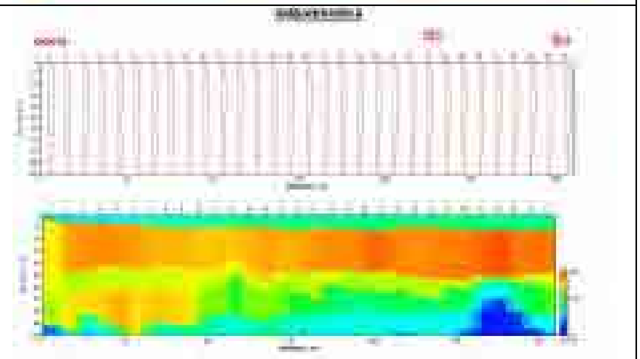
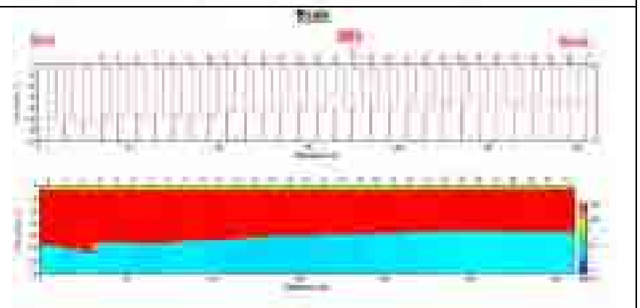
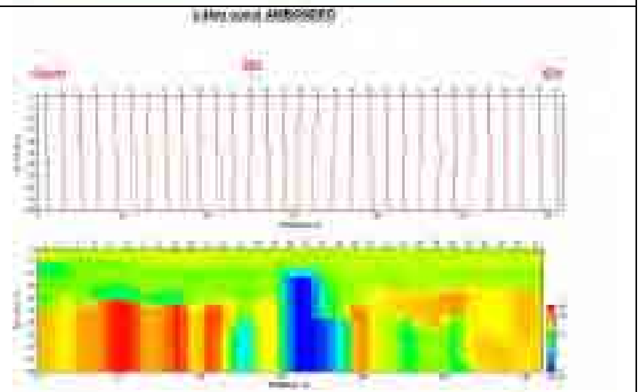
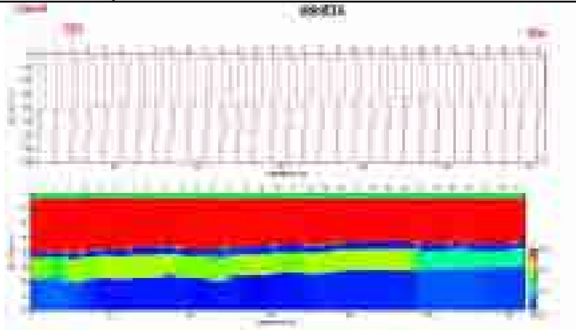
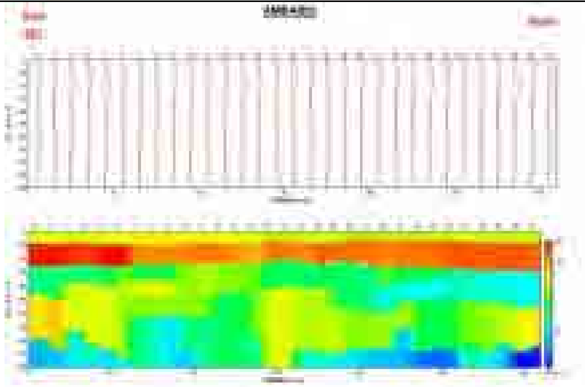
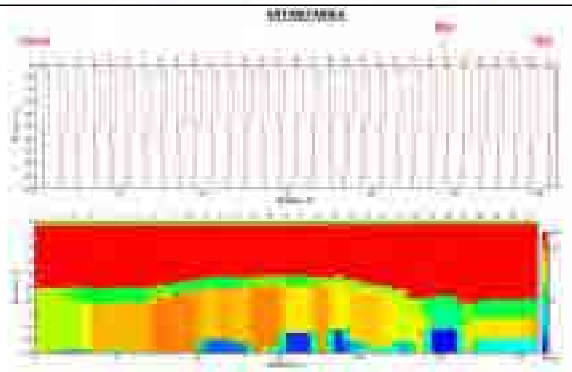
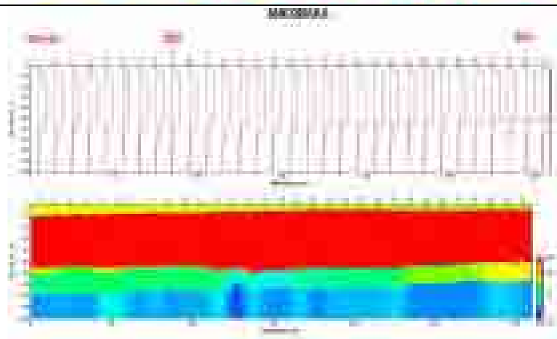
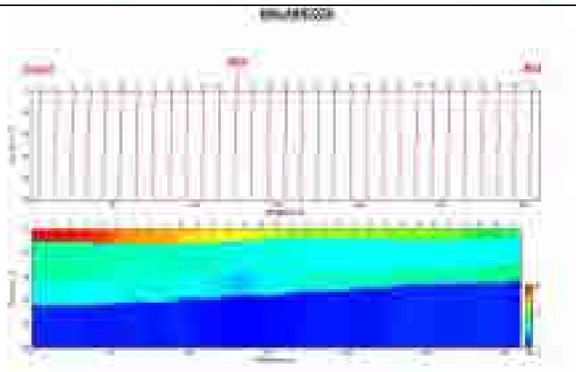
Interpretation	Resistivity cross section
T-23 (W181) Mangarivotra Low resistivity surface layer distributes up to the depth of 7 or 8m. High resistivity layer, thickness of 20m, appears and low resistivity layer, thickness of 20m, appears again. Finally high resistivity layer appears to the deeper part. Previously conducted VES survey results indicate the part deeper than 119m is impermeable layer. Hence deeper high resistivity layer is interpreted as aquifer layer.	
T-24 (W182) Mahavelona Layers clearly divide into two layers at 10m depth at the start point and 17m depth at the end point. The upper layer is 100-200(ohm-m), which can be interpreted as sand layer or sandstone. The lower layer shows low resitivity of under 5(ohm-m) which can be interpreted as effects of saline water.	
T-25 (W183) Ambanisarika (loop length; 25m×25m) Horizontal structure is measured. From the upper part, low resistivity layer, less than 100 (ohm-m), exists up to 4 to 13m deep. High resistivity layer, 300-500 (ohm-m), exists under the low resistivity layer up to 50m deep. Low resistivity layer, less than 100 (ohm-m), appears again under the high resistivity layer. This low resistivity layer indicates existence of saline water or clayey layer. If clayey layer exists, high resistiviy layer above this low resistivity layer is interpreted promising water bearing formation.	
T-26 (W184) Esalo Virtually parallel structure. The surface layer is 4m deep, and 4-40m depth measures high resistivity of 300-400m. These are possibly sandstones. Low resitivity of 10(ohm-m) is possibly effects of saline water.	
T-27 (W185) 4km West Ambondro Layer measuring 10-20(ohm-m) can be seen until 40-50m deep, and beneath this layer measures 100-200(ohm-m). Extremely low resistivity measuring below 1 (ohm-m) can be seen around the central point of the traverse line, 15-19m deep. A layer measuring below 1(ohm-m) cannot be considered under normal circumstances, and the reason is not clear.	

Table 2.2.4-2 Result of interpretation for TEM survey (continued)

Interpretation	Resistivity cross section
T-28 (W186) Anketa The trend of resistivity is same as the result of T-26. Very low resistivuty layer, less than 10 (ohm-m), which distributes from the depth of 60m may be influenced by sea water intrusion.	
T-29 (W187) Ambario Rather high resistivity layer, 100-200(ohm-m), distributes at the depth of 10 to 25 m. This layer is interpreted as sand-gravel layer. However resistivity of deeper layer is 30 to 50 (ohm-m) and this value is rather high as impermeable clay layer. There needs further investigation to conclude this interpretation.	
T-30 (W188) Antaritarika Low resistivity layer, less than 10 (ohm-m), distributes from surface to the depth of 2 – 3m. Higher resistivity layer, 200 (ohm-m), is interpreted as sand stone layer. Very low resistivuty layer, less than 5 (ohm-m), which distributes from the depth of 40m may be influenced by sea water intrusion.	
T-31 (W189) Ankobabe The low resistivity layer measuring 10(ohm-m) below80m, which has the same tendency as T-26, is probably effects of saline water.	
T-32 (W190) Malaindoza Low resistivity layer, less than 100 (ohm-m) distributes all the section. Very low resistivuty layer, less than 5 (ohm-m), may be influenced by sea water intrusion.	

2.2.5 Integrated interpretation

Table 2.2.5-1 summarizes the results of interpretation which are obtained from the three types of geophysical survey.

Table 2.2.5-1 Integrated interpretation of geophysical survey

Area	Integrated interpretation
Central part of the Ambovombe Commune	The distribution of basement rock, aquifer layer and impermeable layer is interpreted by the results of VES survey. Distribution of aquifer layer is also interpreted by the result of IP survey and TEM survey.
Western part of the Ambovombe Commune	The distribution of basement rock and aquifer layer is interpreted by the results of VES survey. Distribution of aquifer layer is also interpreted by the results of TEM survey.
Eastern part of the Ambovombe Commune	The distribution of basement rock and aquifer layer is interpreted by the results of VES survey. Distribution of aquifer layer is also interpreted by the result of TEM survey.
Coastal area	The distribution of basement rock, aquifer layer and impermeable layer is not interpreted by the results of VES survey and TEM survey. Very low resistivity layer is interpreted by VES survey and TEM survey results. This layer thought to be influenced by saline water (sea water). From IP survey result, sand stone layer is interpreted at the deep part.
Central part of the Ambovombe Basin	The distribution of basement rock is interpreted by the results of VES survey. Thickened muddy sediments layer is interpreted by the results of VES survey and TEM survey.
Northern part of the Ambovombe Basin	The distribution of basement rock and aquifer layer is interpreted by the results of VES survey. The distribution of fault zone and weathered zone is interpreted by the results of IP survey and TEM survey.
North end of the Ambovombe Basin	The distribution of basement rock is interpreted by the results of VES survey. The distribution of fault zone and weathered zone is interpreted by the results of IP survey and TEM survey.

2.2.6 Interpreted Hydrogeological Cross Section of Ambovombe Basin

Figure 2.2.6-1 shows location map of cross section and Figure 2.2.6-2 shows interpreted hydrogeological layer for each cross sections.

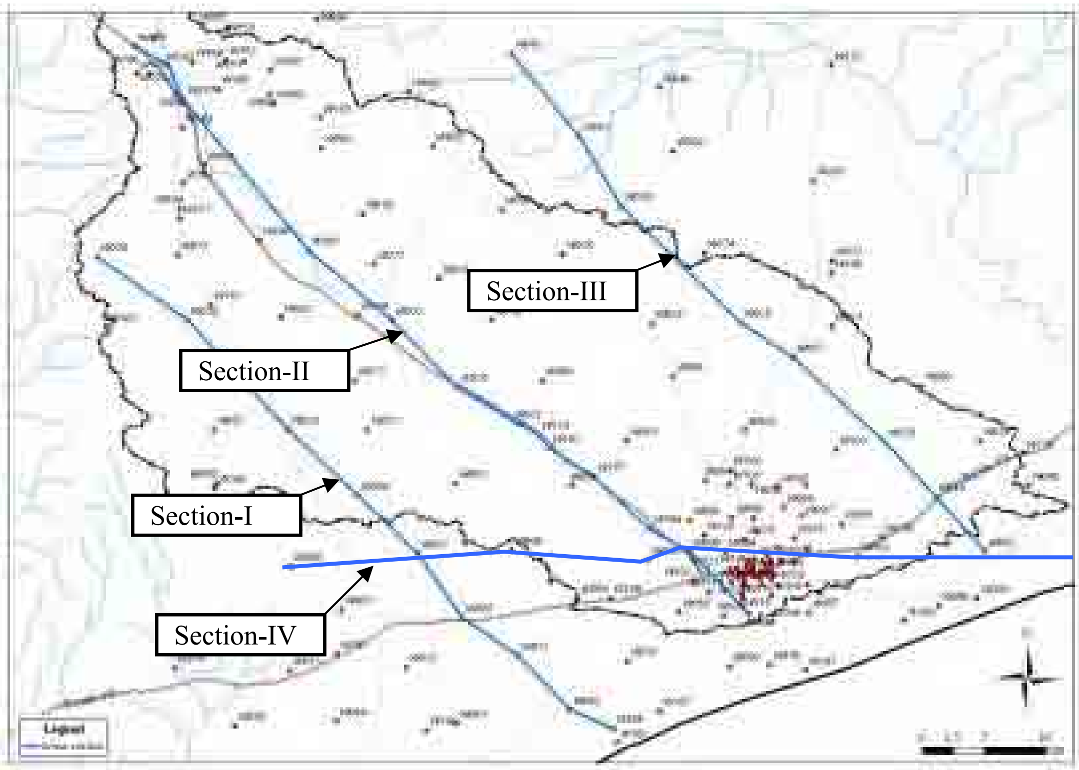


Figure 2.2.6-1 Location map of cross section

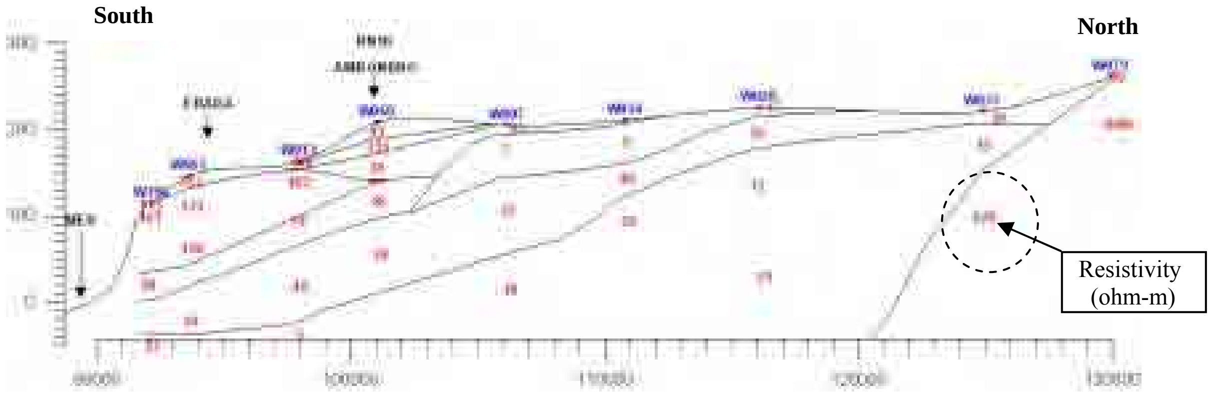


Figure 2.2.6-2 (a) Cross section I

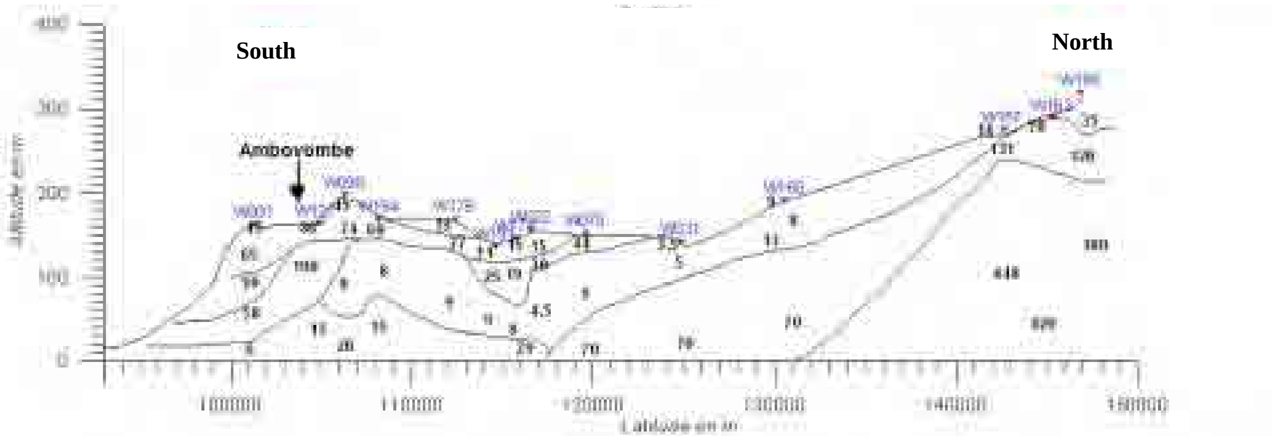


Figure 2.2.6-2 (b) Cross section II

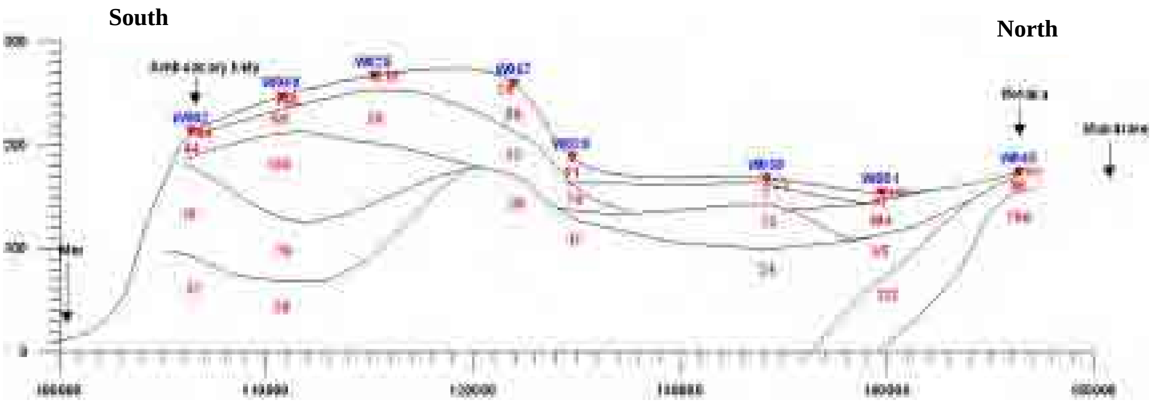


Figure 2.2.6-2 (c) Cross section III

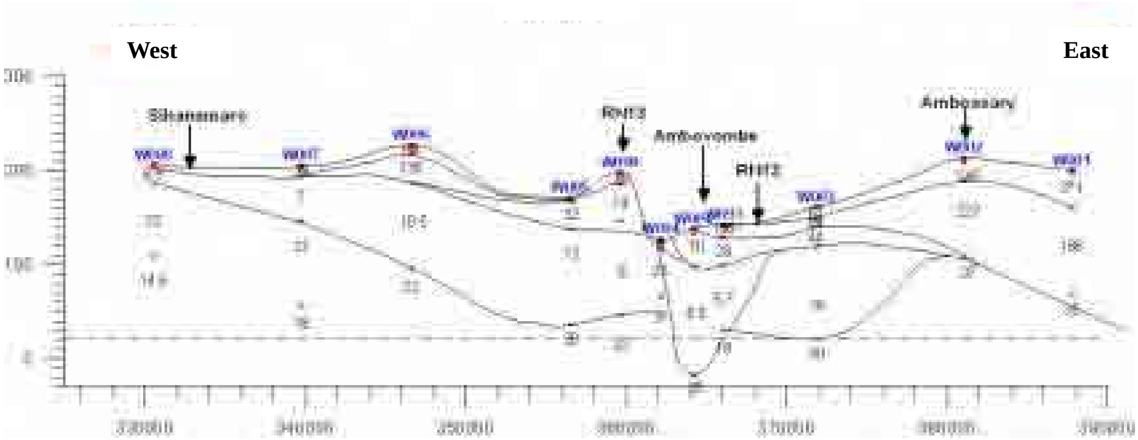


Figure 2.2.6-2 (d) Cross section IV

Basically layers with high resistivity, ex. higher than 200 (ohm-m), represents hydrogeological basement layer. On the other hands, lower resistivity layer represents sedimentary formation. However it is rather difficult to distinguish exactly clay layer and sand layer from sedimentary formation because of saline water intrusion.

****

DP 2.3 Monitoring of Groundwater Level Analysis

2.3.1 Objective

Monitoring of groundwater level is essential to characterize distribution and movement of groundwater within the study area. In general monitoring shall be conducted periodically especially to confirm correlation between groundwater movement and amount of precipitation.

In the study, monthly and seasonal monitoring has been introduced for the selected existing wells which were recognized through the well inventory survey. Furthermore the data which have been obtained from the monitoring can be utilized for the evaluation of groundwater recharge.

In addition to above mentioned existing well, test wells are also added to monthly monitoring program. And automatic groundwater level gauge is installed for some of the test wells.

2.3.2 Monitoring Wells

(1) Seasonal monitoring wells

Seasonal monitoring wells are selected from recognized existing wells within the study area. Firstly sixty (60) wells are selected to monitor groundwater movement within Ambovombe Basin broadly. It is also considered that monitoring data can describe three dimensional distribution of groundwater within the basin. In addition to the selection of sixty (60) wells, ten (10) wells are selected as allowance for probable abandonment of the firstly selected wells. Finally seventy (70) wells are selected as seasonal monitoring well. Table 2.3.2-1 shows the list of seasonal monitoring wells. Figure 2.3.2-1 and 2.3.2-2 shows location map of selected monitoring wells.

(2) Monthly monitoring wells

Sixteen (16) monthly monitoring wells are selected from the selected seasonal monitoring wells. Basically wells are selected equally from upstream to downstream of the Ambovombe Basin to trace time series groundwater fluctuation in terms of response to precipitation. Table 2.3.2-1 also shows the list of monthly monitoring wells. The location of these wells are shown in the Figure 2.3.2-1 and 2.3.2-2.

(3) Monitoring for Test wells

In addition to the above mentioned selected existing wells, groundwater level of test wells, except dried wells, has been monitored. Finally 16 wells are selected for monthly monitoring and automatic groundwater level gauge was installed for 5 wells out of these 16 wells. In addition to the selected 5 test wells, existing well No.604 is also selected for monitoring with automatic groundwater level gauge to compare with characteristics of groundwater level fluctuation of test wells. Table 2.3.2-2 shows the list of monitoring test wells. The locations of these wells are shown in the Figure 2.3.2-3.

2.3.3 Results of Monthly Monitoring

(1) General

Monthly monitoring has been conducted every month from May, 2005 to July, 2006. The monitoring is conducted by local expert of AES Ambovombe and this could be considered as a good opportunity for technical transfer from JICA Study Team.

Table 2.3.2-1 List of Monitoring Wells

Well No.	Elevation (m)	Depth (GL-m)	GWL (GL-m)	EC (mS/m)	Water Use (Lit/day)	Well No.	Elevation (m)	Depth (GL-m)	GWL (GL-m)	EC (mS/m)	Water Use (Lit/day)
Ambovombe area (29 wells)						Antanimora area (25 wells)					
1	143.7	19.4	17.9	580	no data	15	174.4	20.5	14.3	394	200
2	136.1	21.0	19.2	172	24,000	16	198.6	67.9	22.4	170	1,000
3	135.9	28.2	16.9	1,010	no data	17	267.1	36.7	2.7	180	1,000
7	130.1	13.5	12.6	255	900	20	286.5	77.1	4.8	140	13,000
8	134.1	12.8	11.1	199	2,000	22	296.8	23.3	6.6	340	300
10	140.8	14.2	13.8	137	800	26	250.4	41.9	8.6	60	1,300
122	132.5	23.1	17.6	1,420	800	29	262.9	24.8	2.3	333	2,000
123	133.8	14.7	13.2	159	2,000	34	227.7	15.8	2.8	49	800
124	134.5	14.4	13.4	189	2,000	42	285.3	29.8	17.4	102	2,300
134	136.2	26.0	22.3	197	not used	86	158.5	17.0	4.6	678	no data
168	135.8	10.9	10.5	161	1,200	88	293.5	12.2	1.0	262	300
272	140.0	11.1	10.5	142	1,600	97	297	14.1	3.5	306	300
273	137.9	12.6	12.4	563	no data	98	325	17.6	5.3	58	1,300
275	136.7	14.4	14.2	229	800	102	235.3	35.9	13.0	15	no data
276	139.8	16.9	15.7	440	800	103	255.4	34.6	9.7	114	400
277	154.9	25.2	24.8	362	1,000	125	248.4	53.2	15.8	200	1,000
278	138.6	12.8	11.8	183	400	128	208.5	47.8	23.4	556	2,000
283	132.9	7.8	7.4	641	1,000	131	212.3	45.4	28.3	697	800
284	129.8	8.3	7.9	219	600	140	305	15.7	4.3	64	800
285	133.0	11.7	11.7	152	2,000	143	297.5	24.2	8.1	164	2,000
292	137.9	13.0	12.3	394	1,000	148	242	20.3	5.3	235	600
500	135.1	18.6	18.5	107	800	151	195.5	29.5	4.6	803	1,300
505	137.5	13.7	12.8	669	600	152	173	41.9	25.2	487	not used
510	135.8	14.7	14.4	61	300	161	216.3	38.6	14.7	171	2,000
514	130.8	13.9	12.9	66	500	606	141.2	14.3		394	no data
518	132.9	10.8	10.1	318	2,000	Coastal area (3 wells)					
547	142.3	13.0	12.9	1,019	800	165	12.7	-	6.0	997	
604	150.5	129.8	76.2	730	not used	231	52.6	13.0		-	200
605	150.5	18.4	17.6	171	not used	237	52.6	7.3	5.8	1,340	1,000
Ambondro area (13 wells)											
202	221.0	12.1	10.1	439	150						
203	215.2	9.3	3.1	161	4,000						
206	218.0	9.2	2.2	207	no data						
222	210.3	5.6	3.5	312	very small						
227	201.2	8.3	1.6	173	2,000						
228	205.8	5.2	1.5	146	400						
246	217.5	5.0	1.3	131	100						
249	222.1	4.2	2.7	61	100						
253	206.7	11.0	7.5	108	not used						
301	218.9	4.3	1.1	2,020	50						
302	220.8	10.7	2.5	326	150						
600	222.7	4.4	1.1	238	not used						
602	210.8	5.1	3.1	71	100						

*Monthly monitoring wells

*Data in this table is measured in April-05 except water use (measured in October)

Table 2.3.2-2 List of Monitoring Test Wells

No	Well No.	Commune	Depth (m)	Automatic GWL gauge	No	Well No.	Commune	Depth (m)	Automatic GWL gauge
1	FM001	Maroafo	100	-	9	F 022	Anjira	126	-
2	F 001	Fianrenantsoa-Amposy	80	installed	10	F 030	Ekonka	205	installed
3	F 006	Bemamba-Antsatra	78	-	11	P003	Sihannmaro	20	-
4	F 006B	Bemamba-Antsatra	63	installed	12	P009	Ambovome	19	-
5	F 009	Lefonjavy	82	-	13	NW-1	Sihannmaro	31	-
6	F 014	Ankoba-Mikazy	124	-	14	NE-1	Beabo	19	-
7	F 015	Mangarivitra Tananbao	153	installed	15	SW-1	Mitsangana	33	-
8	F 018	Ambanisalika	202	installed	16	SW-2	Ambaro	24	-

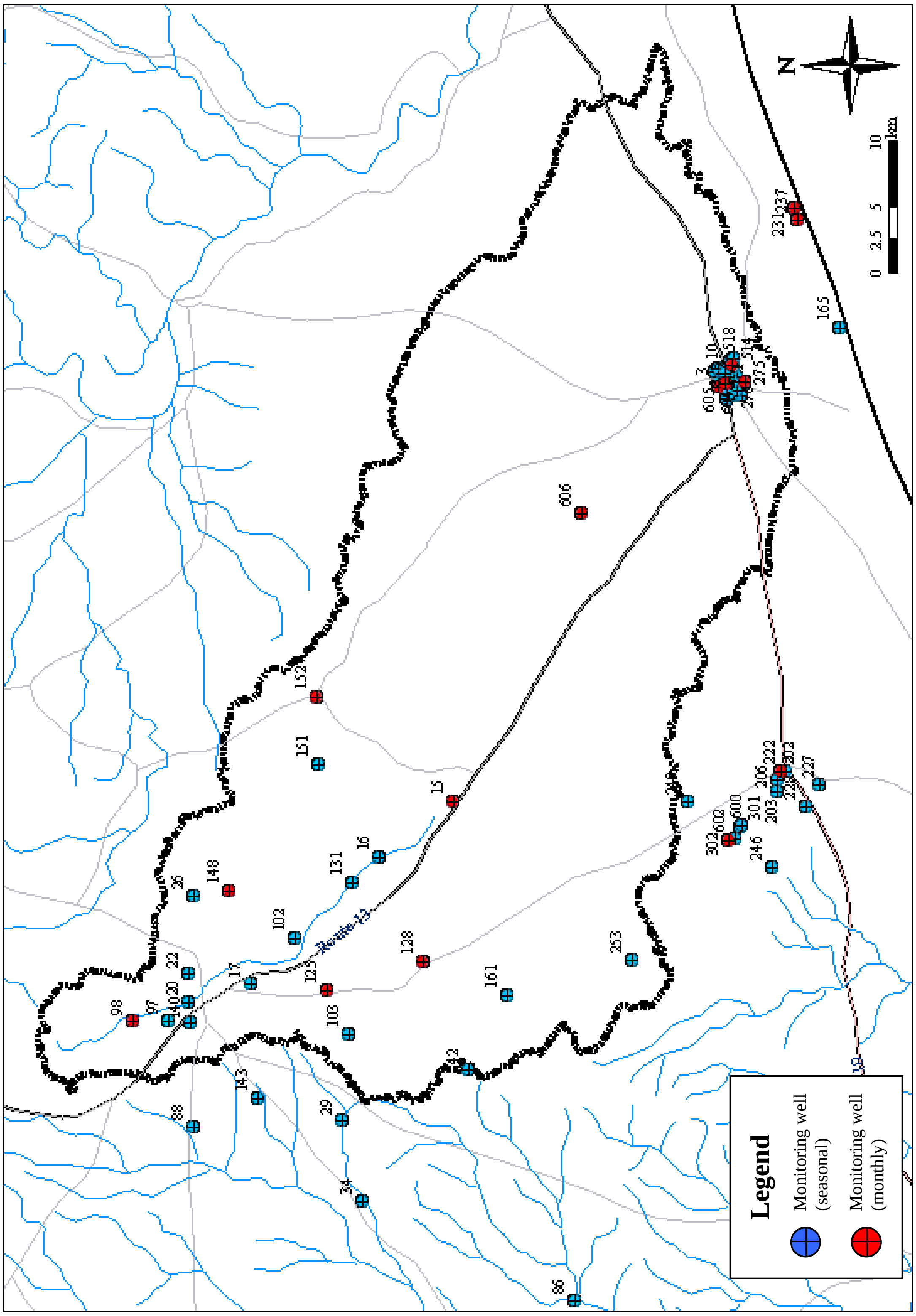


Figure 2.3.2-1 Location map of monitoring well

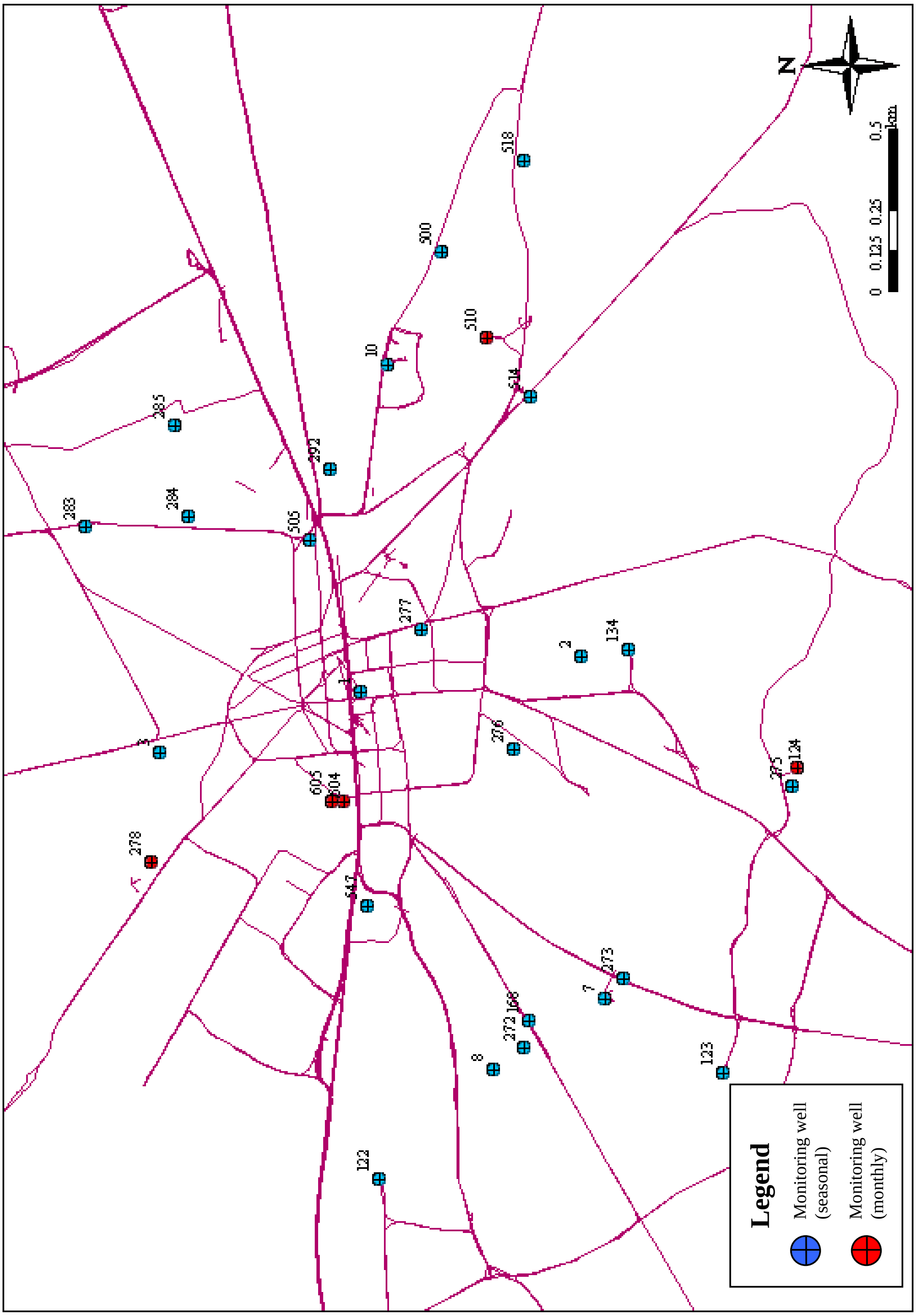


Figure 2.3.2-2 Location map of monitoring well (Ambovombe)

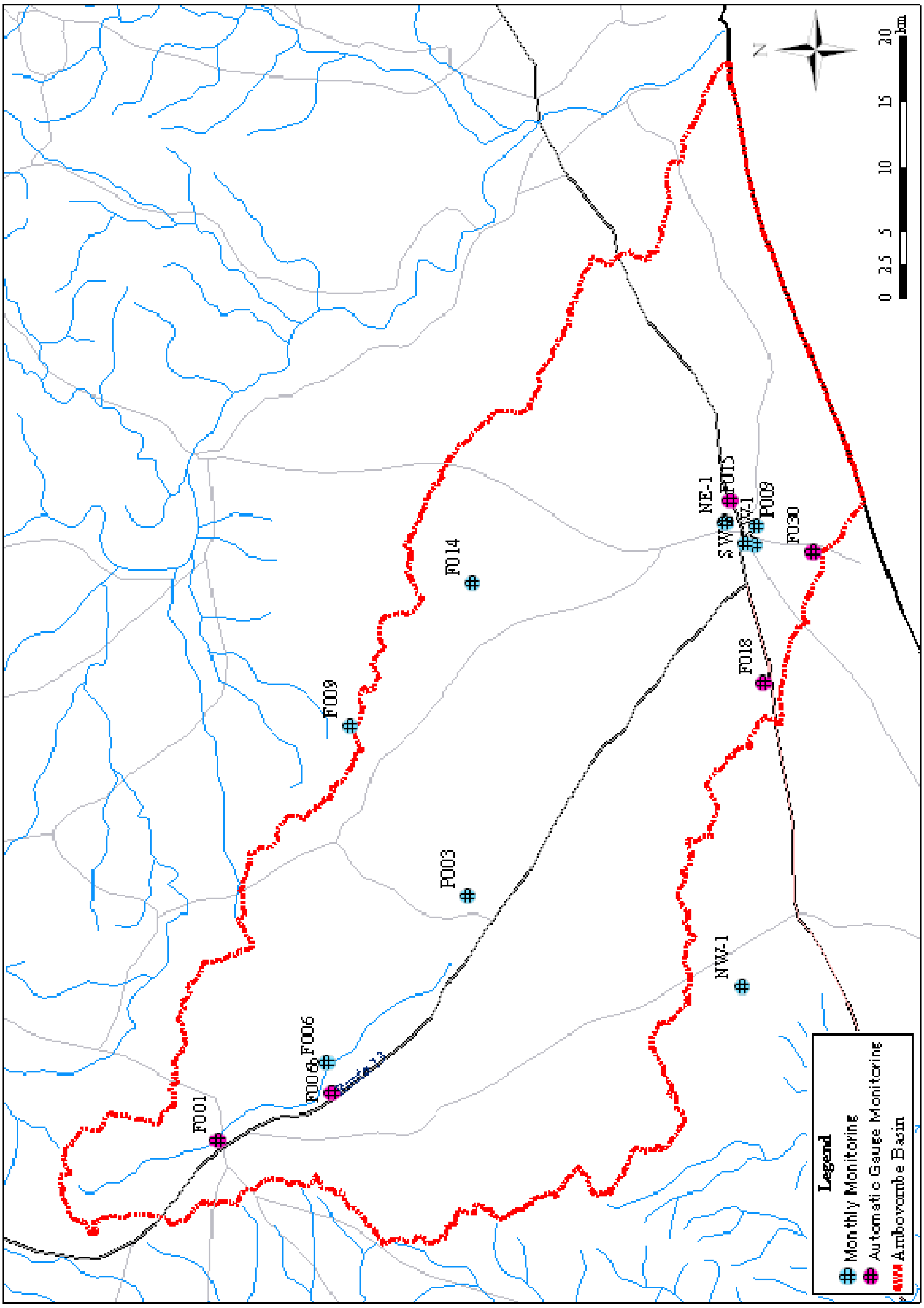


Figure 2.3.2-3 Location map of monitoring well (Test Wells)

(2) Results of Monthly Monitoring

Figure 2.3.3-1 shows fluctuation of groundwater level in contrast with monthly precipitation. Table 2.3.3-1 shows summary of monthly monitoring.

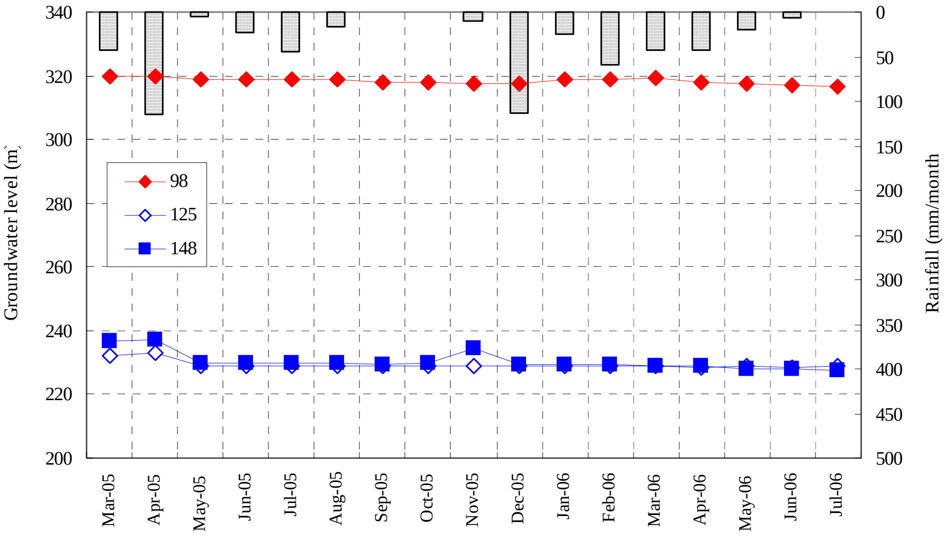


Figure 2.3.3-1 (a) Groundwater level fluctuation (Antanimora area)

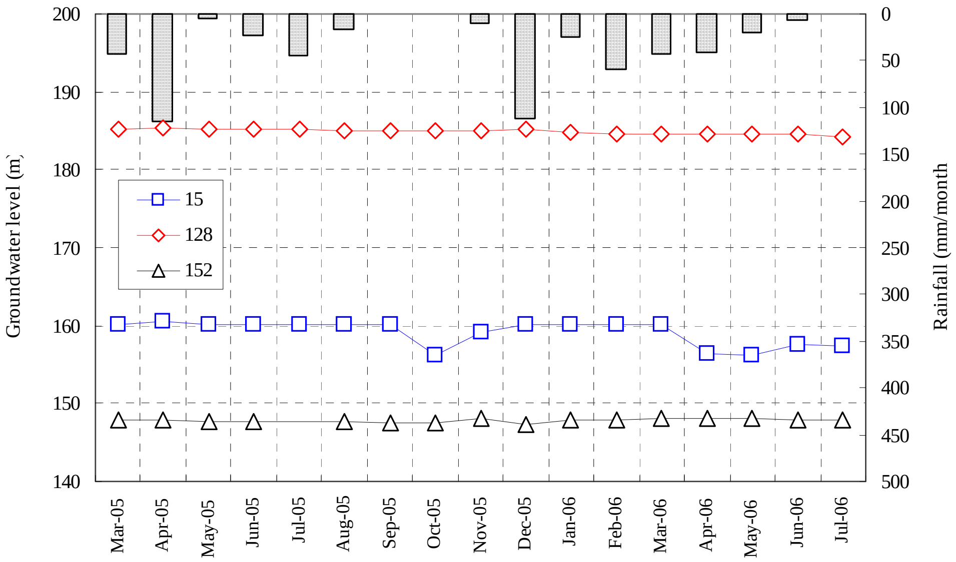


Figure 2.3.3-1 (b) Groundwater level fluctuation (Antanimora area)

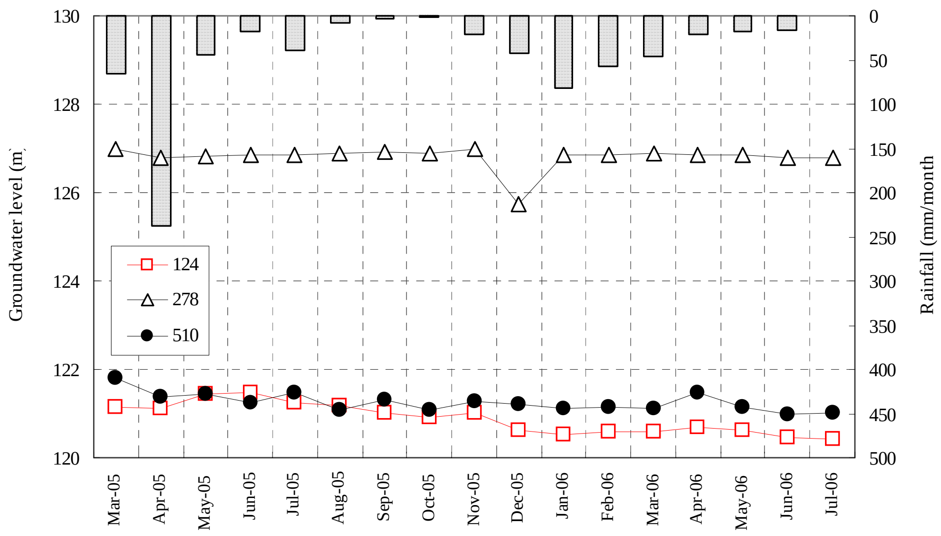


Figure 2.3.3-1 (c) Groundwater level fluctuation (Ambovombe area)

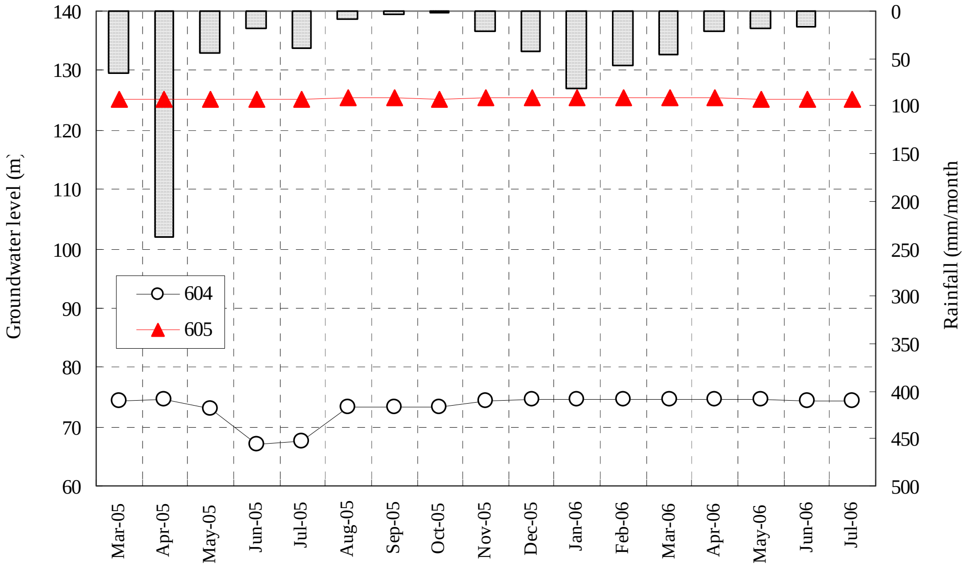


Figure 2.3.3-1 (d) Groundwater level fluctuation (Ambovombe area)

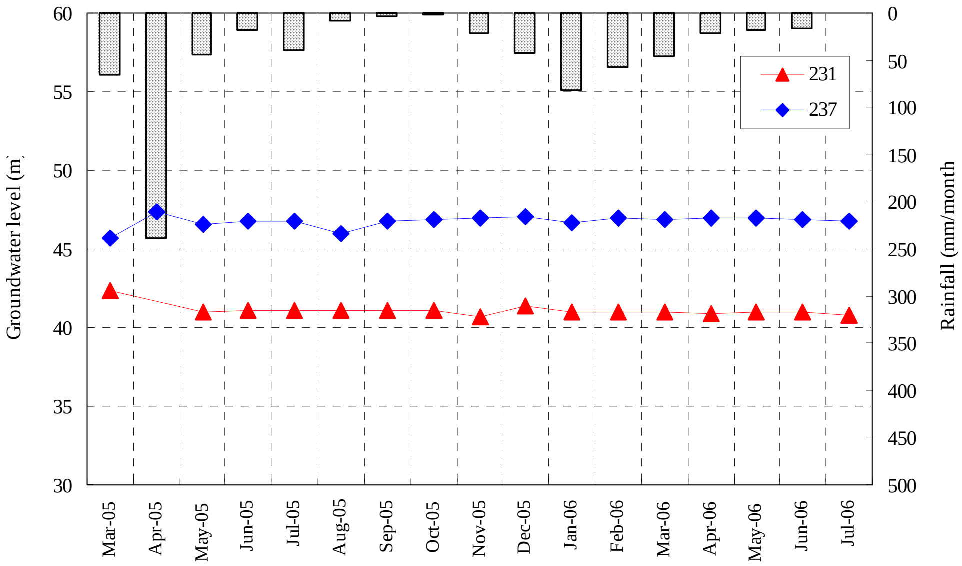


Figure 2.3.3-1 (e) Groundwater level fluctuation (Coastal area)

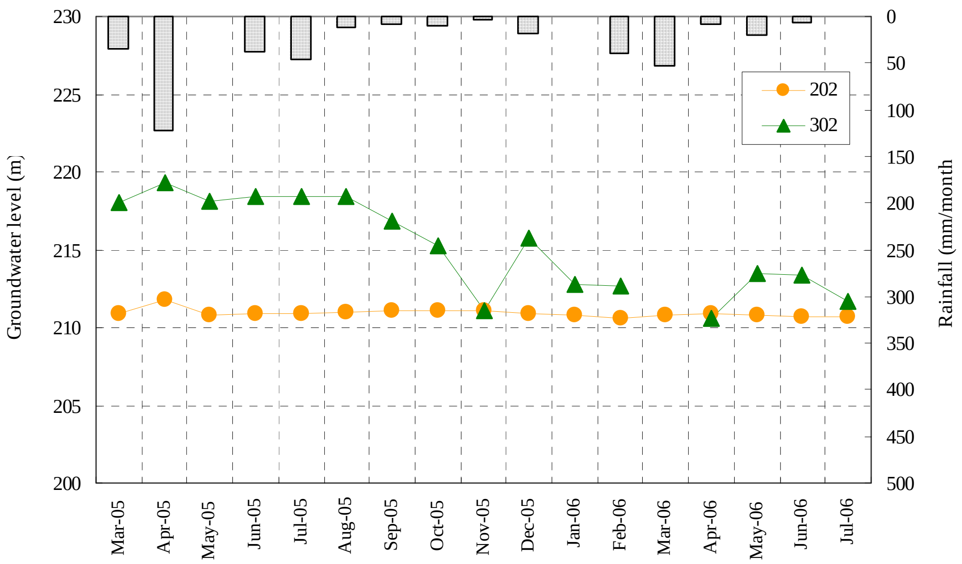


Figure 2.3.3-1 (f) Groundwater level fluctuation (Anbondro area)

Table 2.3.3-1 Summary of Monthly Monitoring

No.		Mar-05	Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06
	Rainfall Ambov	64.95	237.9	44.7	18.3	39.35	7.75	3.1	1.6	21.25	42.85	81.8	56.6	45.5	21.25	18.6	16.25	
	Rainfall Anta	42.8	114.55	4.7	22.6	44.5	16	0	0	9.55	112.35	25.05	59.05	43.4	41.85	19	5.8	
	Rainfall Ambon	35.4	122.4	0	38.5	47	11.05	7.55	9.6	2.75	17.95		38.9	53.25	7.85	20.55	6.45	
1	15	160.12	160.57	160.1	160.12	160.12	160.14	160.08	156.1	159.21	160.14	160.16	160.15	160.11	156.42	156.09	157.51	157.29
2	98	319.69	319.9	318.93	318.66	318.66	318.9	317.77	317.92	317.7	317.55	318.71	319.1	319.37	317.85	317.32	317	316.8
3	**121**				236.28	236.3	235.99	236.04				236	235.88	235.75	235.68	235.64	235.56	235.58
4	124	121.15	121.1	121.45	121.48	121.25	121.19	121.03	120.92	121.03	120.63	120.54	120.6	120.6	120.68	120.62	120.45	120.42
5	125	232.17	233.09	229.11	229	229.02	228.99	229.08	228.94	229.01	228.99	229.01	228.88	228.76	228.67	228.73	228.63	228.72
6	128	185.14	185.33	185.18	185.22	185.18	185.05	185.07	184.96	184.98	185.19	184.73	184.62	184.55	184.54	184.67	184.57	184.14
7	148	236.7	237.22	230.01	229.97	229.98	229.78	229.15	229.66	234.22	229.49	229.4	229.27	228.88	228.69	228.11	227.9	227.67
8	152	147.8	147.95	147.73	147.72		147.76	147.59	147.41	148.05	147.38	147.98	147.97	148	148	148.01	147.92	147.91
9	202	210.9	211.74	210.77	210.9	210.94	210.96	211.05	211.08	211.07	210.9	210.8	210.61	210.82	210.87	210.76	210.7	210.66
10	231	42.4		41	41.03	41.04	41.07	41.05	41.03	40.73	41.4	40.97	41.01	40.96	40.89	40.96	40.94	40.81
11	237	45.7	47.33	46.57	46.76	46.75	46.02	46.73	46.83	46.95	47.05	46.7	46.95	46.9	46.92	46.94	46.9	46.8
12	**262**																	
13	278	126.98	126.79	126.83	126.85	126.84	126.9	126.91	126.9	126.97	125.75	126.85	126.84	126.88	126.84	126.84	126.79	126.78
14	302	218.03	219.28	218.16	218.38	218.4	218.43	216.83	215.22	211.12	215.76	212.82	212.66		210.57	213.5	213.32	211.73
15	510	121.8	121.39	121.45	121.26	121.49	121.07	121.31	121.07	121.28	121.2	121.13	121.15	121.13	121.47	121.15	121	121.03
16	**514**						117.83	117.55	117.61	118.05								
17	**603**							129.99		115.48								
18	604	74.3	74.55	72.92	67.12	67.66	73.2	73.19	73.2	74.22	74.61	74.62	74.51	74.51	74.47	74.54	74.4	74.4
19	605	125.23	125.23	125.25	125.25	125.25	125.3	125.31	125.25	125.34	125.35	125.38	125.4	125.35	125.33	125.27	125.2	125.26
20	606											137.16	124.77	121.7	121.56	121.5		
21	P003										155.35	155.35	155.2	155.2	155.2	155.17	155.25	154.53
22	P009												100.4				100.9	
23	F001												216.3	217.2	217.2	217.1		216.8
24	F006												216.9	216.7	216.9	216.9	216.1	216.1
25	F006B												218.7	218.8	218.7	218.7	218.6	218.4
26	F009												130.6	129.4	117.2	117.6	117.7	117.4
27	F014												79.7	79.9	79.9	79.9	79.9	79.6
28	F015										6.3	6.3	6.2				6.2	
29	F018										62.0	62.1	62.1	61.6	61.6	61.7	61.7	61.5
30	FM001													10.4	10.4	10.4	10.3	10.1
31	F022													19.3	19.2	19.1	19.0	18.7
32	F030											4.6	4.7	4.6	4.6	4.6	4.7	2.4
33	SW-1												98.4	98.6	98.6	98.6	98.6	98.3
34	SW-2													111.1	111.1	111.0	111.0	110.7
35	NE-1													101.4	102.7	104.7	106.1	106.0
36	NW-1													188.7	188.6	188.5	188.5	188.3

Figure 2.3.3-1 (a) shows the trend of groundwater level of the well No.98 indicates gradual lowering from April to October, 2005. However, the groundwater level had been increasing toward the level of April. There are significant decreasing of groundwater level in May, 2005 for the well No.125 and 148. It may caused by a small amount of rainfall. Figure 2.3.3-1 (b) shows the trend of groundwater level is almost stable. However the trend for the well No.15 indicates significant lowering in October, 2005. Figure 2.3.3-1 (c) shows the trend of groundwater level has different characteristic. The trend of the well No.278 indicates gradual uprising from April to November, 2005. The trend of the remaining two wells (No.124 and 510) shows direct response to the amount of rainfall. Figure 2.3.3-1 (d) shows the different trend of groundwater level between well No.604 and No.605. The well No.604 is deep well (130m deep) and the aquifer is considered as confined aquifer. On the other hands, well No.605 is shallow well (17.7m deep), which located beside the well No.604, and the aquifer is considered as unconfined aquifer. The trend of groundwater level of shallow well (No.605) indicates almost flat. On the other hands, deep well (No.604) indicates lowering of groundwater level in June and July, 2005. There is no apparent relationship between groundwater levels and precipitation. Figure 2.3.3-1 (e) shows the trend of groundwater level indicates almost stable for the well No231. There is slight relationship between groundwater levels and precipitation for the well No.237. Figure 2.3.3-1 (f) shows the trend of groundwater level has different characteristic. There is significant lowering of groundwater levels for these two wells in May, 2005. And from May to August, 2005 there are slight uprising of groundwater levels for them. However from August to October, 2005, groundwater level of the well No.202 still keeps on uprising then it is decreasing. On the other hands, groundwater level of the well No.302 suddenly goes down and it is uprising in December, 2005.

(3) Detailed Discussion

a) Antanimora Area

Figure 2.3.3-2 shows detailed location map of monitoring wells in Antanimora Area with geological classification. Figure 2.3.3-3 shows fluctuation of groundwater level for each monitoring wells.

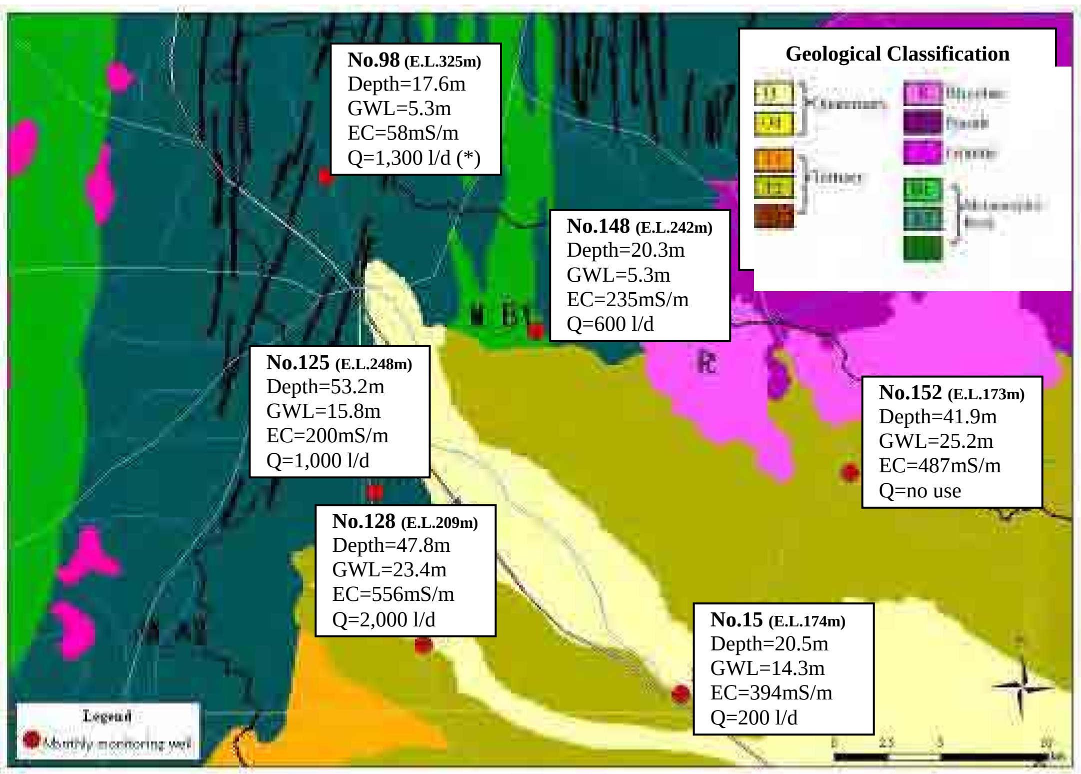


Figure 2.3.3-2 Detailed location map of monitoring well in Antanimora Area

(*) Q: Quantity of water use from the well

In this area, three wells, No.98, 125 and 148, are located in the metamorphic rock distributed area. Remaining three wells, No.15, 128 and 152, are located in the sedimentary formation distributed area.

For the rock distributed area, according to the Figure 2.3.3-3, from April to May, 2005, there is significant lowering of groundwater level for the well No.125 and 148. This lowering is though to be caused by some kind of external factor (increment of water use, etc.). If this lowering is caused by less amount of rainfall, there shall be similar direct response in accordance with amount of rainfall for continuing period.
Accordingly through a process of exclusion of such an external factor, groundwater level fluctuation of monitoring well has almost similar characteristics.
Especially groundwater level fluctuation of the well No.98 has most drastic fluctuation. And it is supposed that this trend is caused by amount of precipitation.
Due to shallow depth of groundwater level and direct response by amount of precipitation, the well No.98 is thought to be located in unconfined aquifer. And remaining two wells in rock area is thought to be located in the similar aquifer because of similar trend of groundwater level fluctuation. However some of the well is thought to be located in semi-confined aquifer because of small magnitude of fluctuation.

For sedimentary formation distributed area, trend of groundwater fluctuation is almost same. There are similar trend of groundwater level fluctuation of the well No.15, 128, and 152. Accordingly hydrigeological conditions of these wells are thought to be similar one.

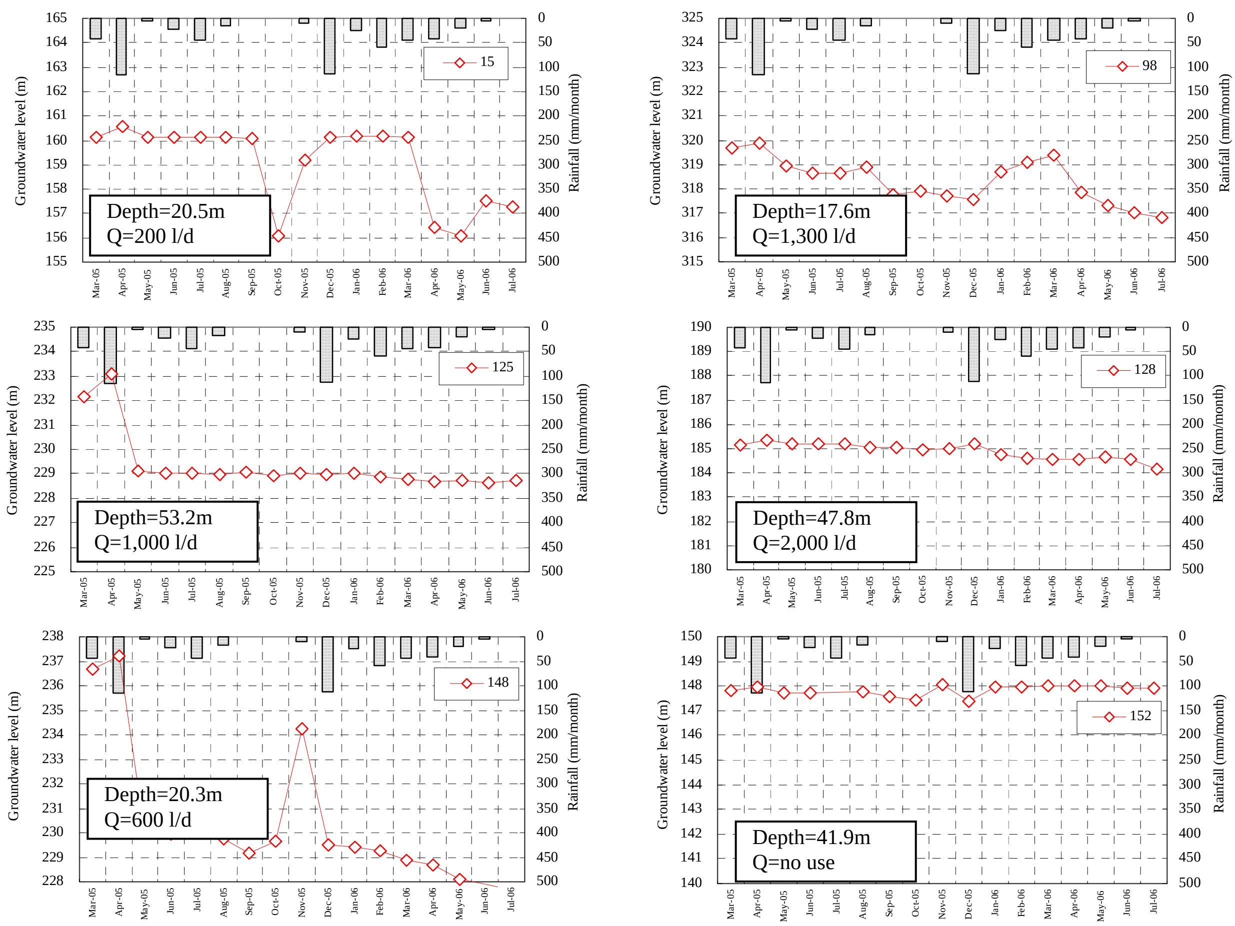


Figure 2.3.3-3 GWL of each monitoring wells in Antanimora Area

b) Ambovombe Area

Figure 2.3.3-4 shows detailed location map of monitoring wells in Ambovombe Area with geological classification. Figure 2.3.3-5 shows fluctuation of groundwater level for each monitoring wells.

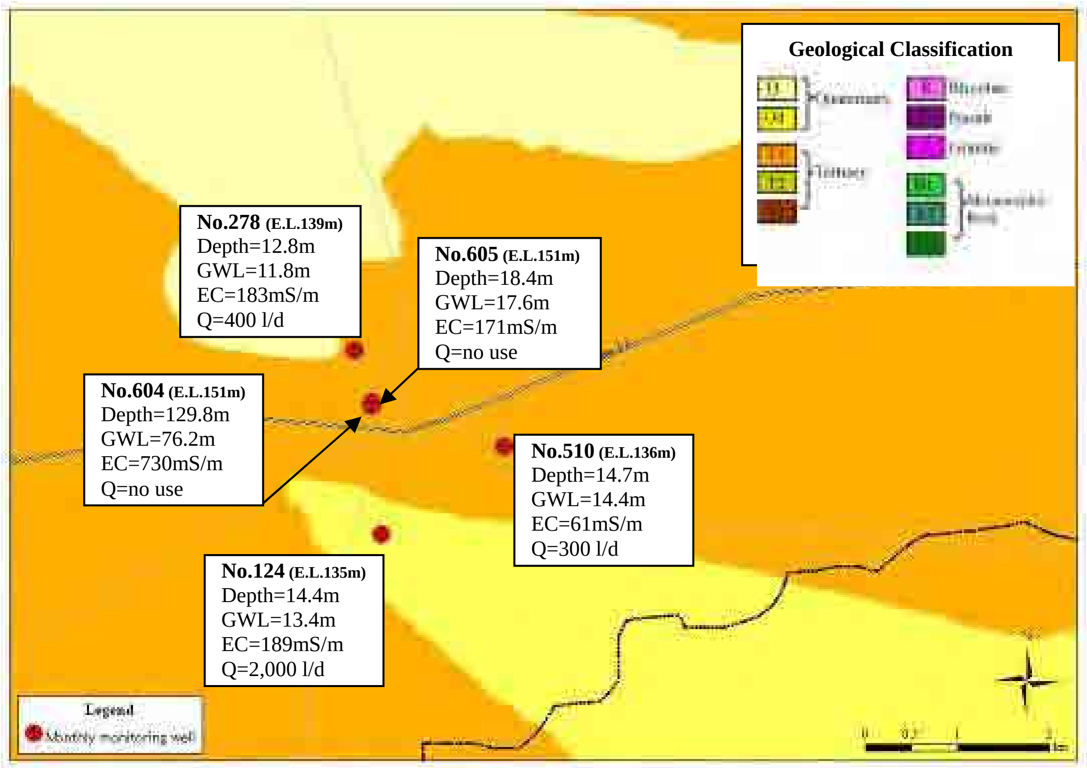


Figure 2.3.3-4 Detailed location map of monitoring well in Ambovombe Area

All the monitoring wells are located in center or surrounding of Ambovombe city. Except the well No.604, all the wells are shallow well. These shallow wells are located in unconfined aquifer and the deep well is located in confined aquifer.

From Figure 2.3.3-5, trend of groundwater fluctuation indicates different characteristics.
Groundwater level fluctuation of the well No.278 and 510 indicates uprising from August to October even in the dry season.

There is no apparent relationship between groundwater level fluctuations for the well No.604 (deep well) and 605 (shallow well).
The reason of lowering of groundwater level for the well No.604 is not clear.

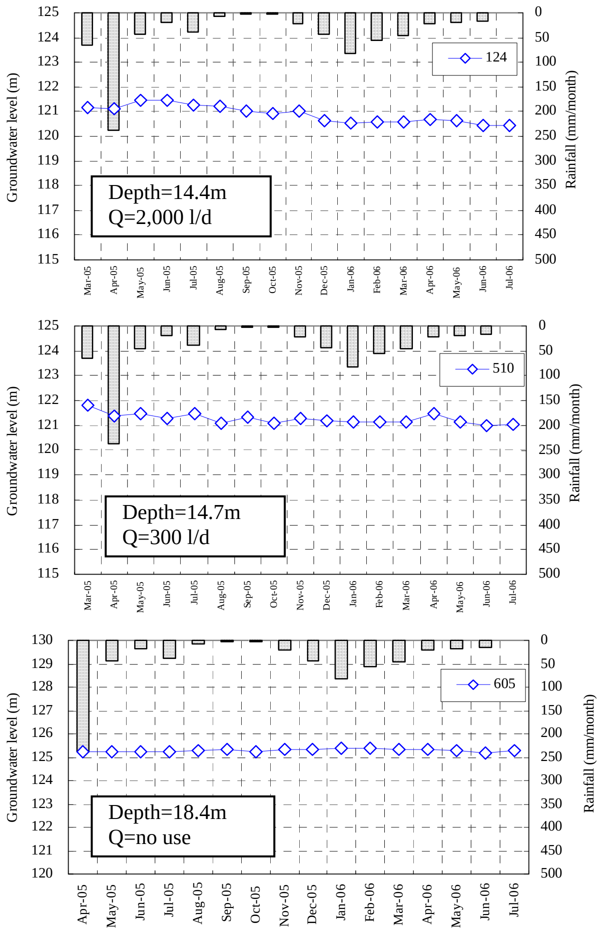


Figure 2.3.3-5 GWL of each monitoring wells in Ambovombe Area

c) Coastal Area

Figure 2.3.3-6 shows detailed location map of monitoring wells in Coastal Area with geological classification. Figure 2.3.3-7 shows fluctuation of groundwater level for each monitoring wells.

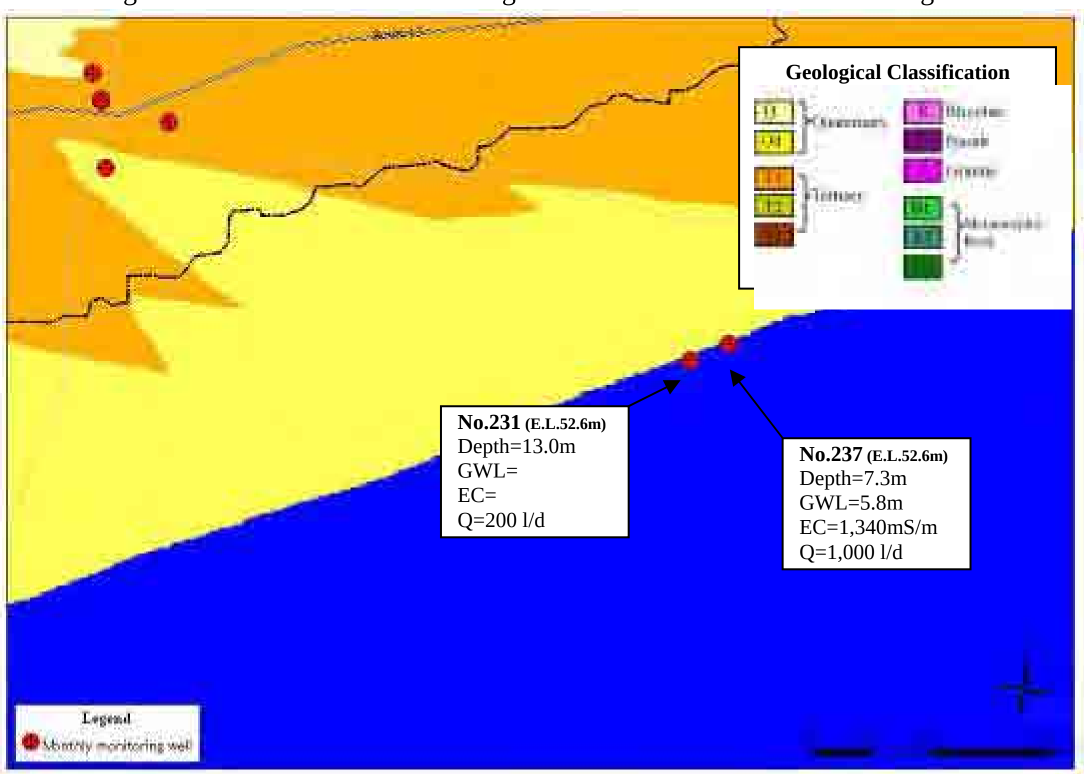


Figure 2.3.3-6 Detailed location map of monitoring well in Coastal Area

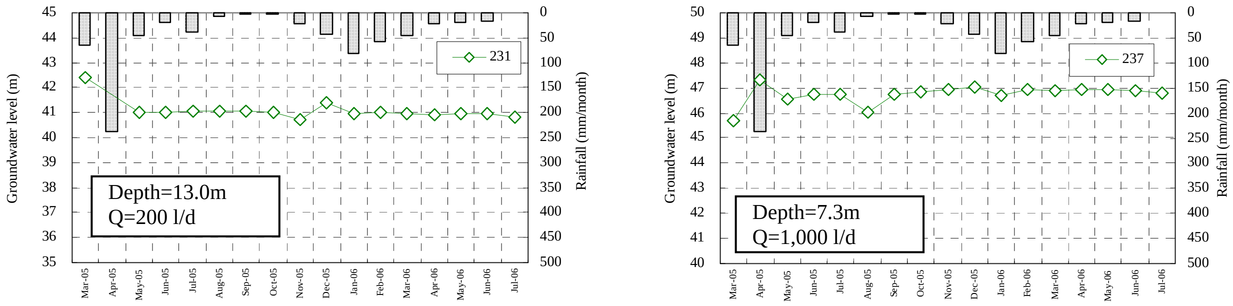


Figure 2.3.3-7 GWL of each monitoring wells in Coastal Area

Two monitoring wells are located beside seashore. These wells are located in unconfined aquifer. Groundwater level fluctuation of the well No.231 indicates flat. On the other hands, groundwater level fluctuation of the well No.237 indicates more drastic change.

d) Anbondro Area

Figure 2.3.3-8 shows detailed location map of monitoring wells in Anbondro Area with geological classification. Figure 2.3.3-9 shows fluctuation of groundwater level for each monitoring wells.

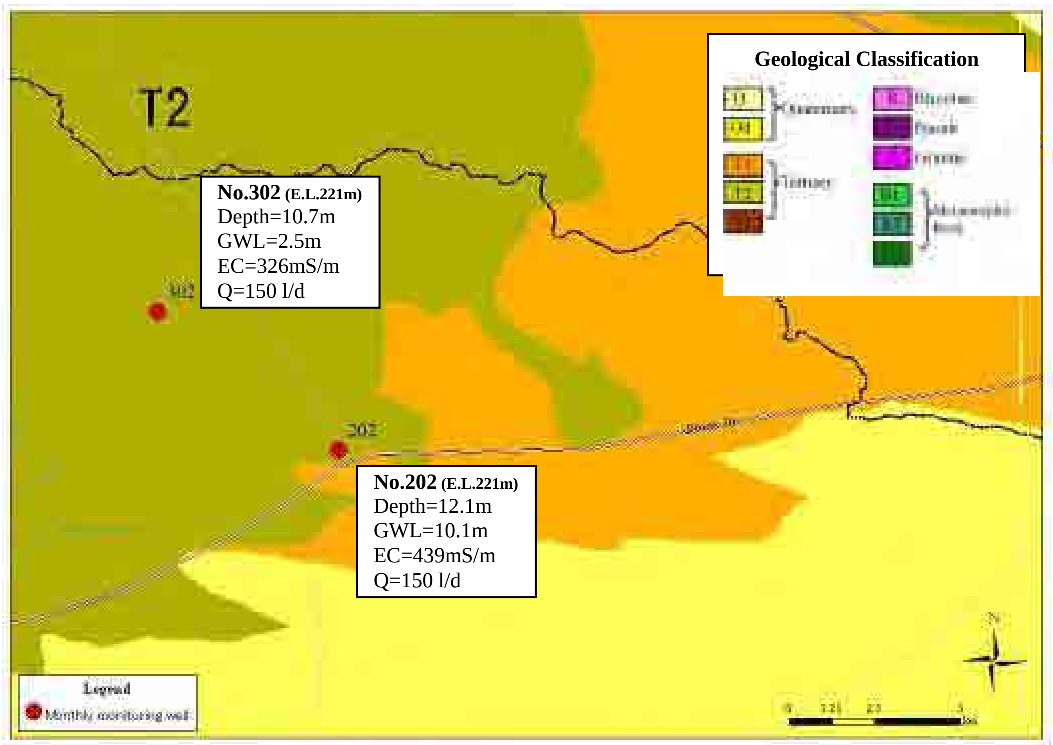


Figure 2.3.3-8 Detailed location map of monitoring well in Anbondro Area

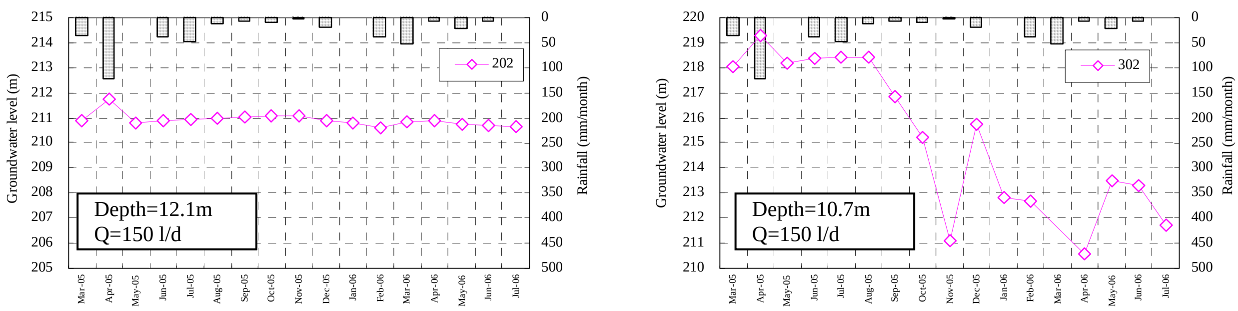


Figure 2.3.3-9 GWL of each monitoring wells in Anbondro Area

Two monitoring wells are located in Ambondro area. These wells are located in sedimentary formation distributed area. The aquifer of these wells is classified into unconfined aquifer.

2.3.4 Results of Seasonal Monitoring

(1) General

Seasonal monitoring has been conducted totally three times in this study. The first was conducted in April and the second was conducted in July and the last was conducted in October, 2005.

Table 2.3.4-1 shows summarized results of the seasonal monitoring.

(2) Comparison between measured data

Table 2.3.4-2 shows summary of the comparison between measured data. Figure 2.3.4-1 shows histogram of fluctuation of groundwater level between each measured period.

Table 2.3.4-1 Summary of the comparison between measured data

Item	Groundwater level (m)		
	Apr.-Jul.	Jul.-Oct.	Apr.-Oct.
Number of samples	56	56	64
Minimum	-12.62	-4.92	-7.59
Maximum	2.19	5.76	1.86
Average	-0.98232	-0.04054	-1.13328

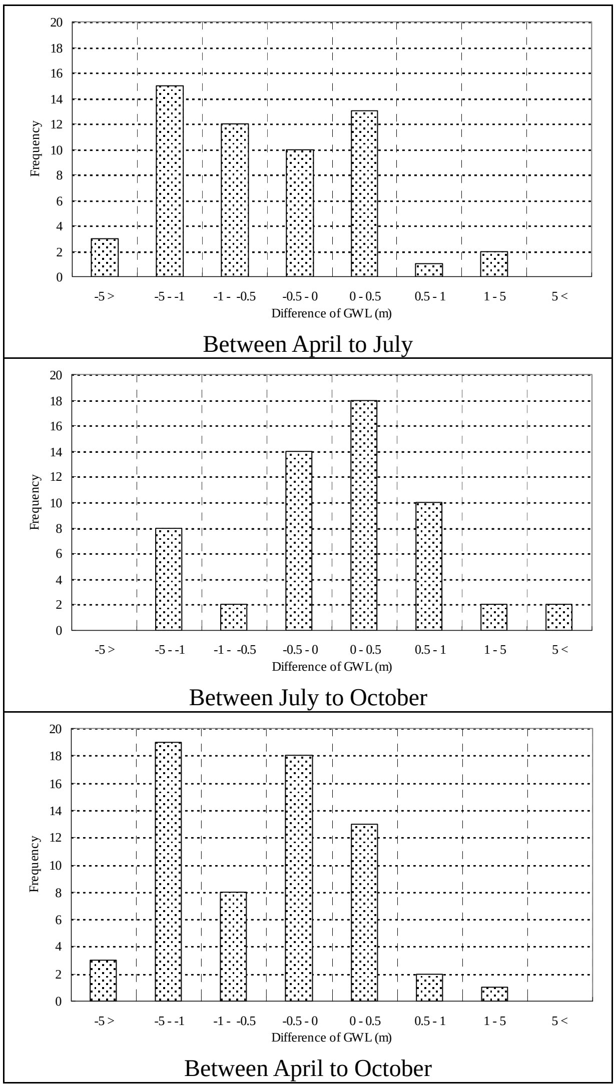


Figure 2.3.4-1 Histogram of fluctuation of groundwater level

Table 2.3.4-2 Results of seasonal monitoring (Groundwater level)

(Unit : GL-m)

Well No.	Elevation (m)	Depth (GL-m)	Measured in April	Measured in July	Measured in October	Well No.	Elevation (m)	Depth (GL-m)	Measured in April	Measured in July	Measured in October
Ambovombe area (29 wells)						Antanimora area (25 wells)					
1	143.7	19.4	17.9	17.6	17.7	15	174.4	20.5	14.3	14.3	18.3
2	136.1	21.0	19.2	19.2	19.6	16	198.6	67.9	22.4	24.2	24.4
3	135.9	28.2	16.9	17.8	17.9	17	267.1	36.7	2.7	4.0	3.9
7	130.1	13.5	12.6	13.0	13.0	20	286.5	77.1	4.8	4.9	5.7
8	134.1	12.8	11.1	11.8	11.9	22	296.8	23.3	6.6	18.5	14.2
10	140.8	14.2	13.8	13.5	13.7	26	250.4	41.9	8.6	9.8	12.9
122	132.5	23.1	17.6	17.6	17.8	29	262.9	24.8	2.3		3.7
123	133.8	14.7	13.2	13.0	13.3	34	227.7	15.8	2.8		7.4
124	134.5	14.4	13.4	13.3	13.6	42	285.3	29.8	17.4		20.2
134	136.2	26.0	22.3	22.1	22.2	86	158.5	17.0	4.6		
168	135.8	10.9	10.5	8.4	8.6	88	293.5	12.2	1.0	1.5	1.7
272	140.0	11.1	10.5		10.7	97	297	14.1	3.5	4.3	4.8
273	137.9	12.6	12.4	12.0		98	325	17.6	5.3	6.3	7.1
275	136.7	14.4	14.2	13.9	14.2	102	235.3	35.9	13.0	10.3	14.7
276	139.8	16.9	15.7	15.6	15.7	103	255.4	34.6	9.7	0.0	10.2
277	154.9	25.2	24.8	24.0	23.8	125	248.4	53.2	15.8	19.4	19.5
278	138.6	12.8	11.8	11.8	11.7	128	208.5	47.8	23.4	23.3	23.5
283	132.9	7.8	7.4	7.3	7.6	131	212.3	45.4	28.3	28.4	28.4
284	129.8	8.3	7.9	7.7	7.8	140	305	15.7	4.3	4.5	5.0
285	133.0	11.7	11.7	11.2	11.6	143	297.5	24.2	8.1	8.0	8.2
292	137.9	13.0	12.3	12.3	12.3	148	242	20.3	5.3	12.0	12.3
500	135.1	18.6	18.5	18.0	18.1	151	195.5	29.5	4.6		
505	137.5	13.7	12.8	12.6	13.2	152	173	41.9	25.2		25.6
510	135.8	14.7	14.4	14.3	13.7	161	216.3	38.6	14.7		14.6
514	130.8	13.9	12.9	13.0	13.2	606	141.2	14.3			
518	132.9	10.8	10.1	9.4	10.0	Coastal area (3 wells)					
547	142.3	13.0	12.9	12.6	12.6	165	12.7	-	6.0		
604	150.5	129.8	76.2	82.8	77.3	231	52.6	13.0		11.6	11.6
605	150.5	18.4	17.6	17.6	17.6	237	52.6	7.3	5.8	5.9	5.8
Ambondro area (13 wells)											
202	221.0	12.1	10.1	10.1	9.9						
203	215.2	9.3	3.1	3.5	7.0						
206	218.0	9.2	2.2	2.4	8.2						
222	210.3	5.6	3.5	4.0	5.9						
227	201.2	8.3	1.6	1.9	3.0						
228	205.8	5.2	1.5	2.0	2.2						
246	217.5	5.0	1.3		4.8						
249	222.1	4.2	2.7	2.9	3.0						
253	206.7	11.0	7.5		8.1						
301	218.9	4.3	1.1	1.7	2.4						
302	220.8	10.7	2.5	2.4	5.6						
600	222.7	4.4	1.1	1.5	1.8						
602	210.8	5.1	3.1	2.3	4.4						

*Monthly monitoring wells

According to the Table 2.3.4-2 and Figure 2.3.4-1, from April to July, 2005, groundwater level of most monitoring well go down. On the other hands, from July to October, 2005, groundwater levels go up for some of the monitoring well.
However groundwater levels of most monitoring wells go down between April and October, 2005.

Figure 2.3.4-2 shows histogram of fluctuation of groundwater level between each measured period in Antanimora area and Ambovombe area.
According to the Figure 2.3.4-2, compare with characteristics between the groundwater level fluctuation observed in Antanimora and Ambovombe, the range of fluctuation of groundwater level is larger for the monitoring wells in Antanimora and groundwater levels of most monitoring wells go down between April and October, 2005 in Antanimora.

On the other hands, in Ambovombe area, for only the half of monitoring wells, groundwater levels go down between April and October, 2005 and it's of remaining wells go up.

Figure 2.3.4-3 shows distribution of groundwater level fluctuation in the study area from April to October.
According to the Figure 2.3.4-3 (c), in Ambovombe area, the monitoring wells with uprising characteristic seems mainly located in eastern part, and wells with lowering characteristics seems mainly located in western part between April and October, 2005.

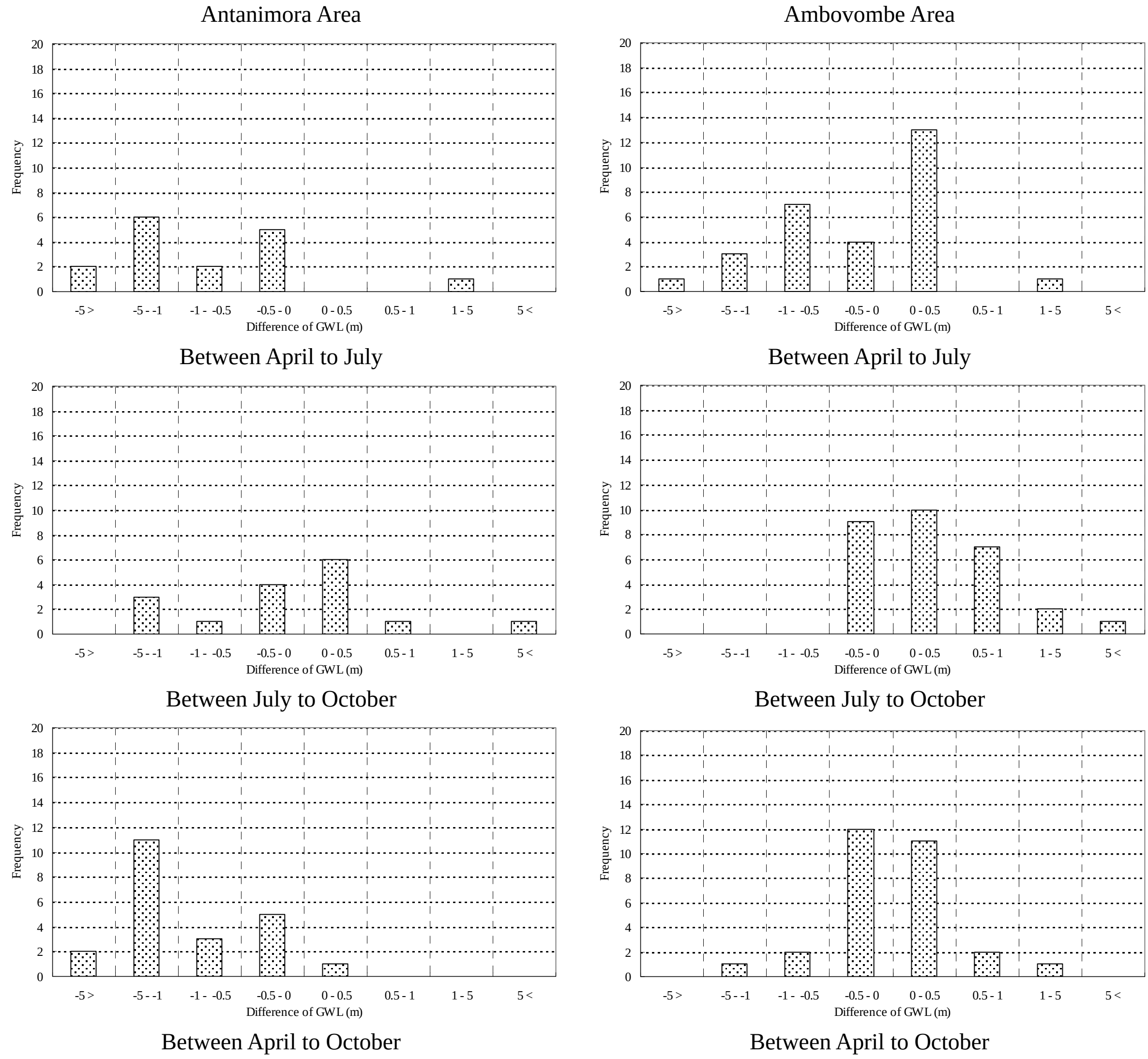
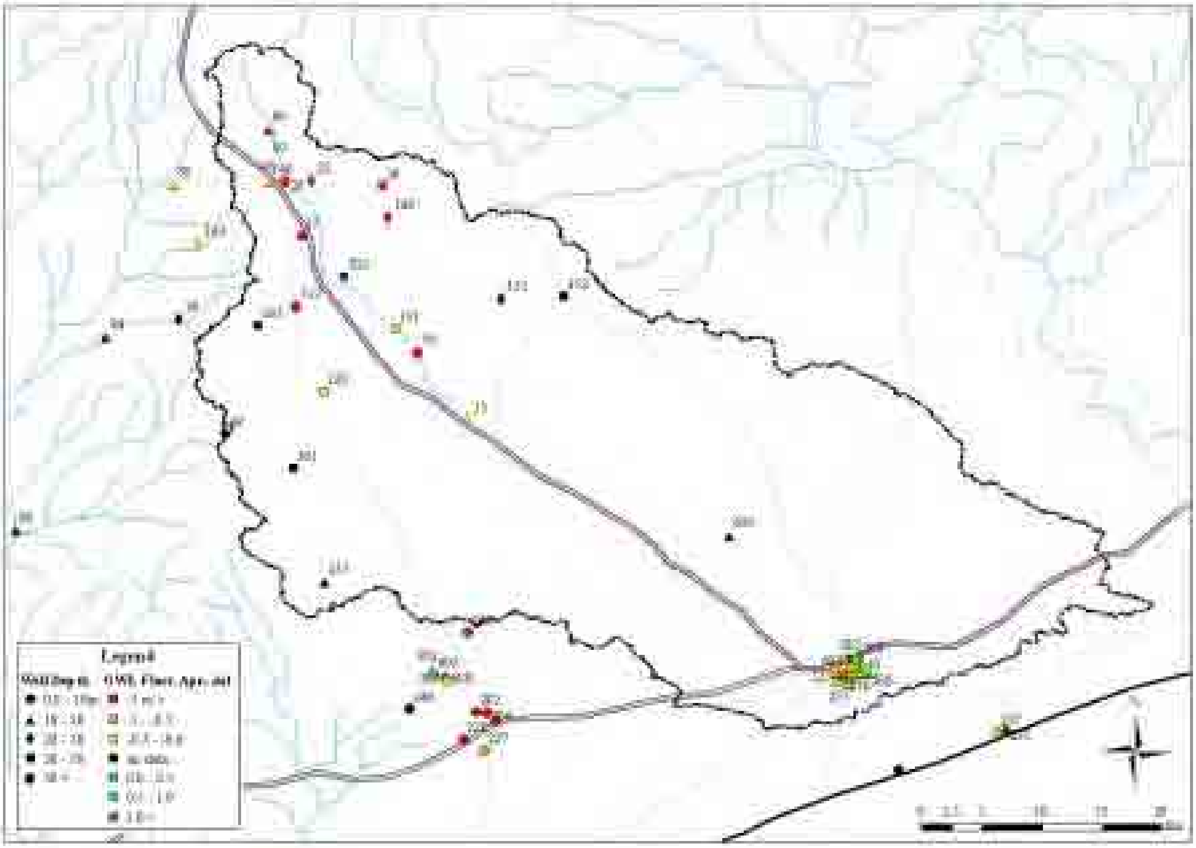


Figure 2.3.4-2 Histogram of fluctuation of groundwater level for Antanimora and Ambovombe Area



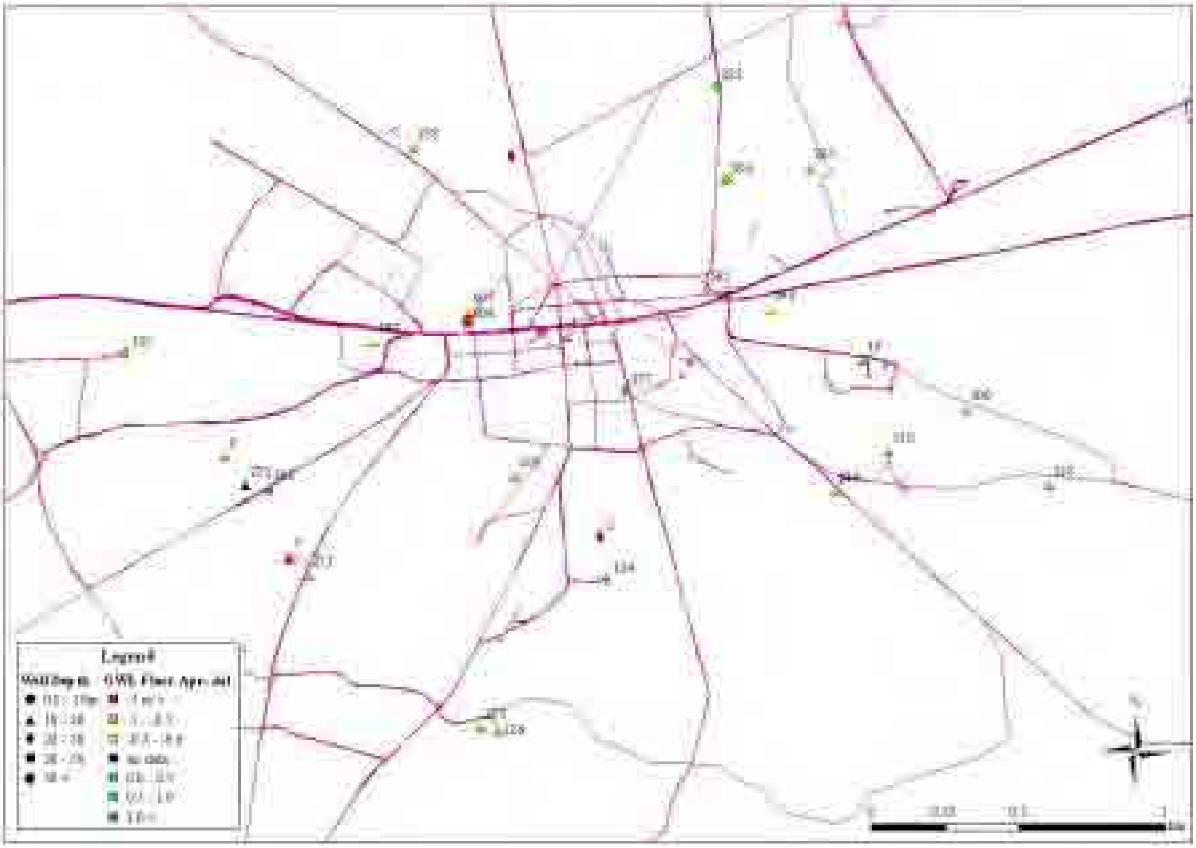


Figure 2.3.4-3 (a) Groundwater level fluctuation distribution map (from April to July)

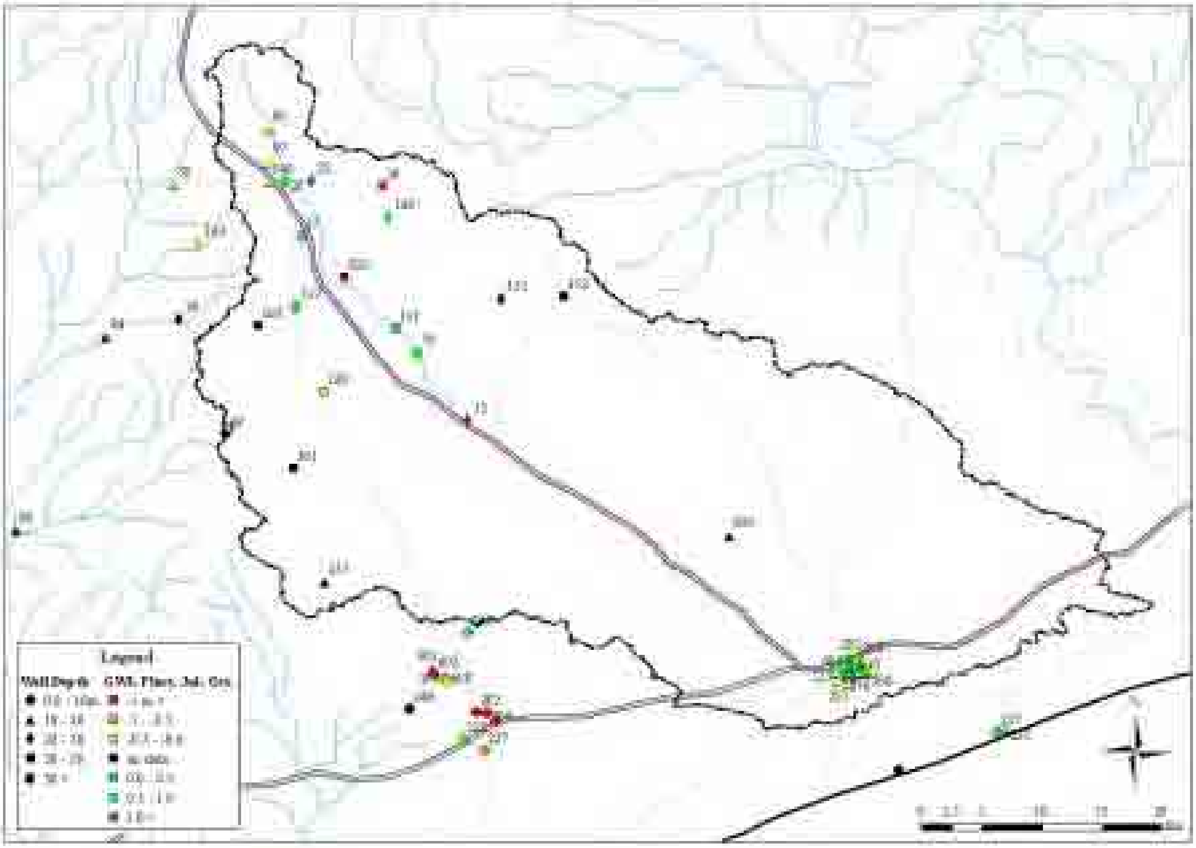
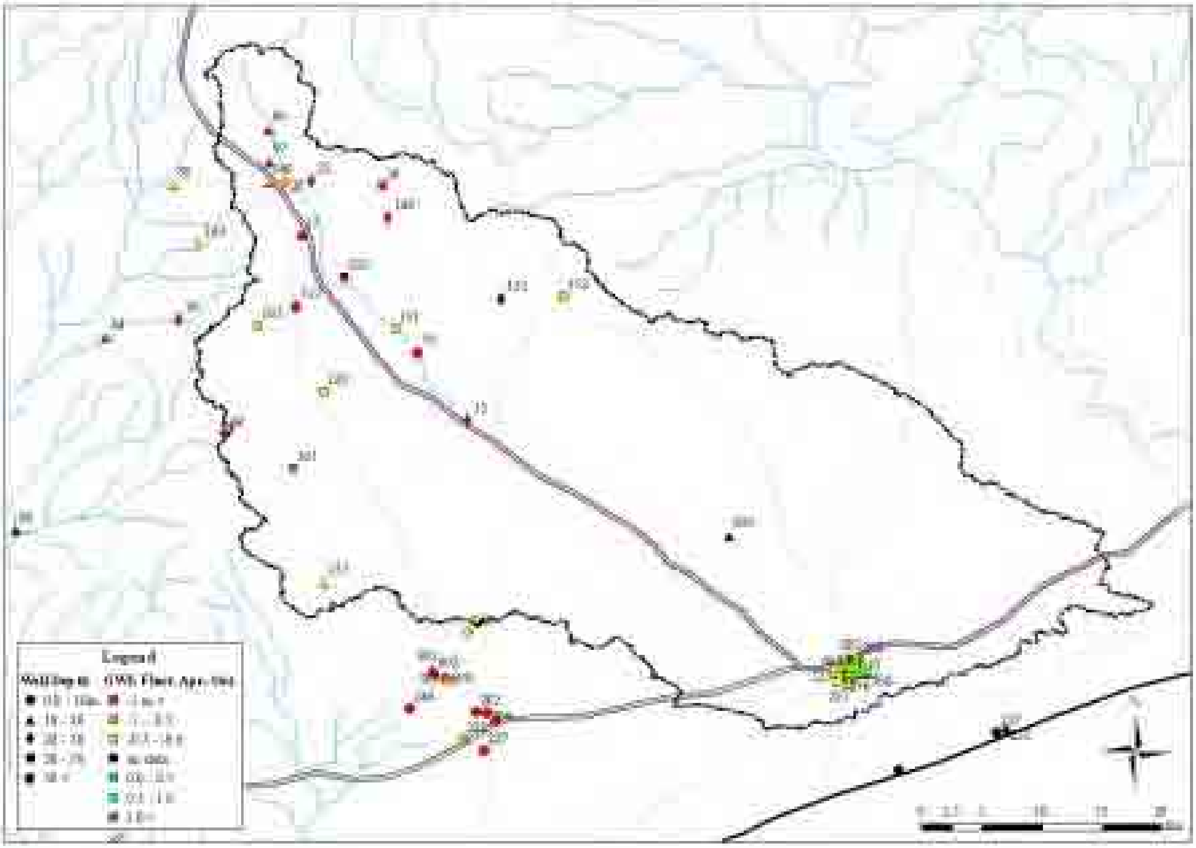


Figure 2.3.4-3 (b) Groundwater level fluctuation distribution map (from July to October)



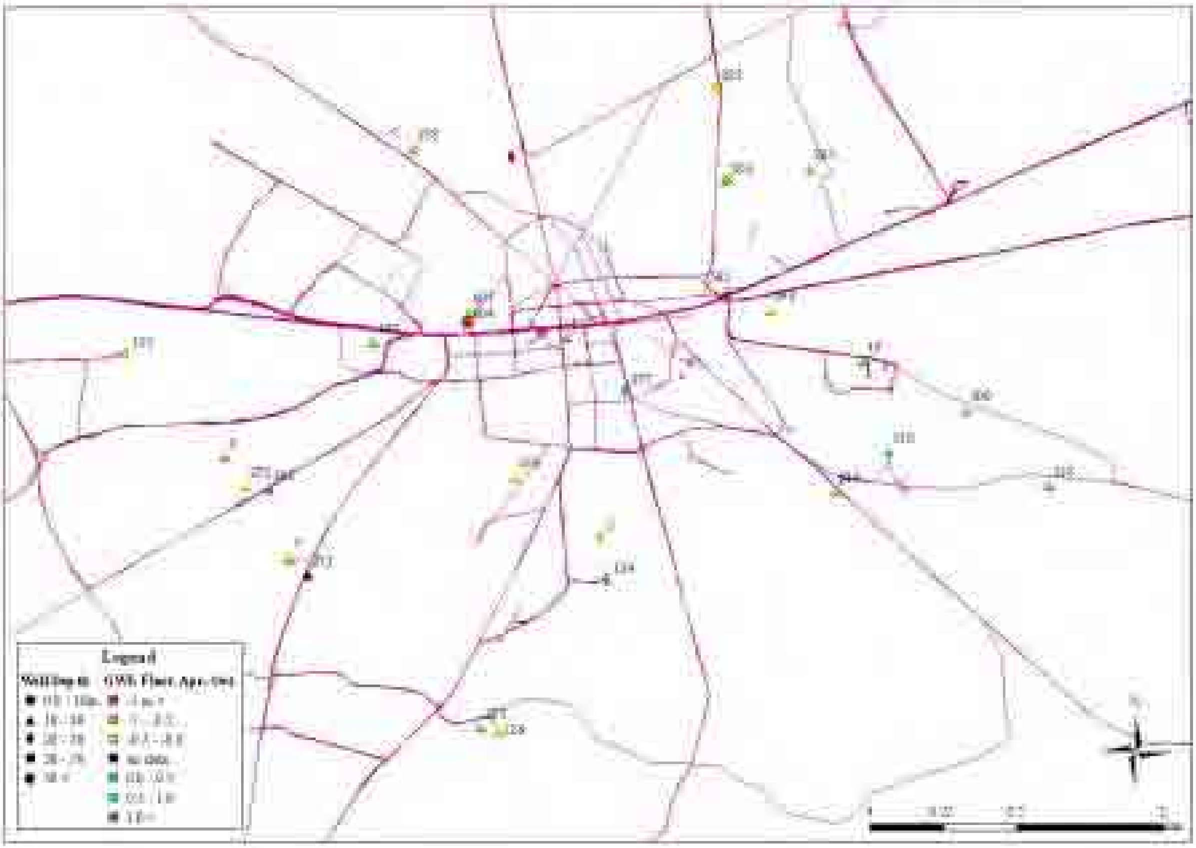


Figure 2.3.4-3 (c) Groundwater level fluctuation distribution map (from April to October)

(3) Contour map of groundwater level

Figure 2.3.4-4 and 2.3.4-5 shows contour map of groundwater level for Ambovombe Area and Antanimora Area from April to October, 2005 respectively. For Antanimora Area, due to insufficient number of the data, distribution in July is excluded.

According to the Figure 2.3.4-4, basically there is not so significant change of groundwater level distribution between each monitoring period. Higher groundwater level is located in the center of the map through all the monitoring period. And in the south-western part, there is lowering of groundwater level especially in October, 2005.

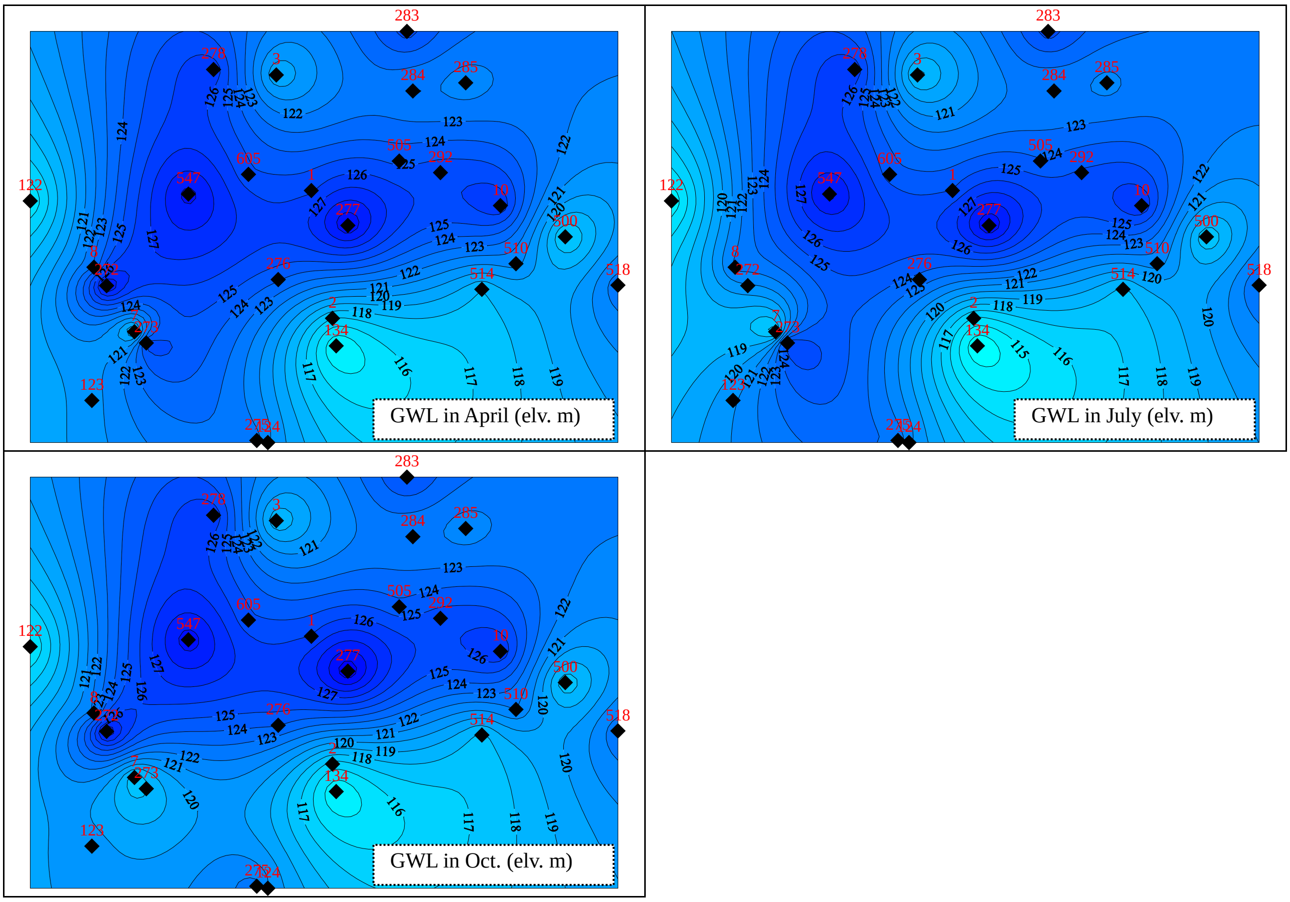


Figure 2.3.4-4 Contour map of groundwater level in Ambovombe Area

According to the Figure 2.3.4-5, groundwater level is gradually go down from north-west to south-east. This tend is coincide with topography of this area. Compare with the distribution in April and in October, 2005, there is lowering of groundwater level in the western part of the map.

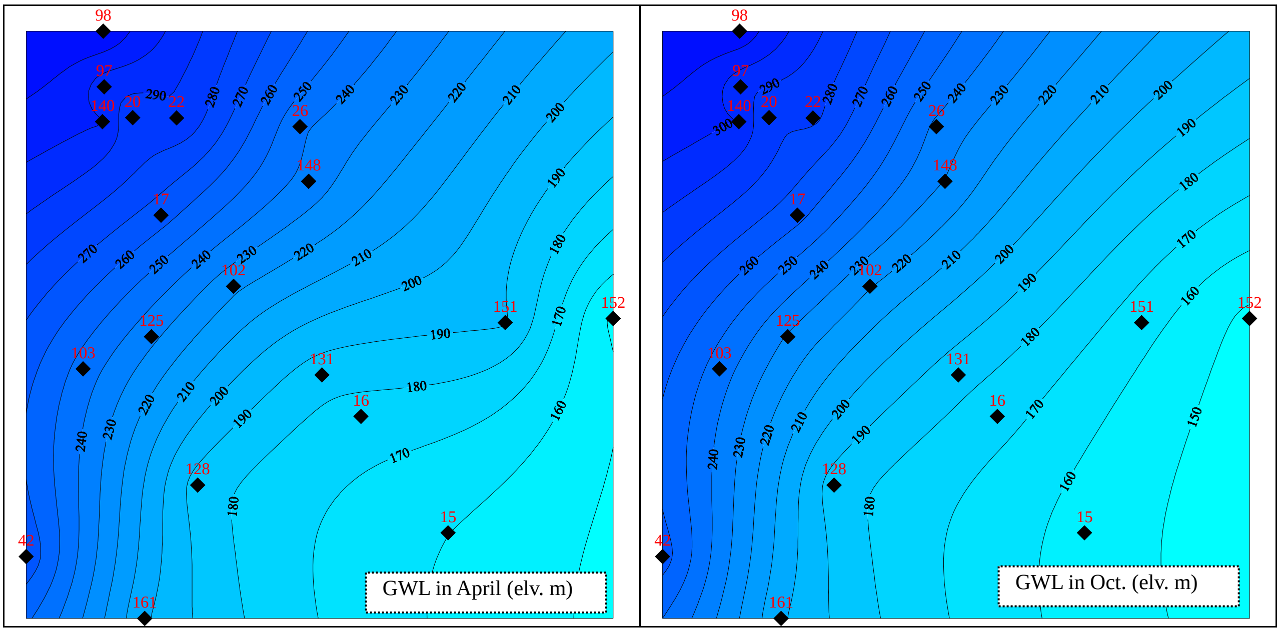


Figure 2.3.4-5 Contour map of groundwater level in Antanimora Area

2.3.5 Results of Monitoring for Test Wells

(1) Results of Monthly Monitoring

Figure 2.3.5-1 shows fluctuation of groundwater level in contrast with monthly precipitation (results of monthly monitoring is summarized in the Table 2.3.3-1).

a) Antanimora Area

Groundwater levels of three test wells have been monitored. The results show gradual decreasing of groundwater level from April to July, 2006. This may be caused by decrease of precipitation.

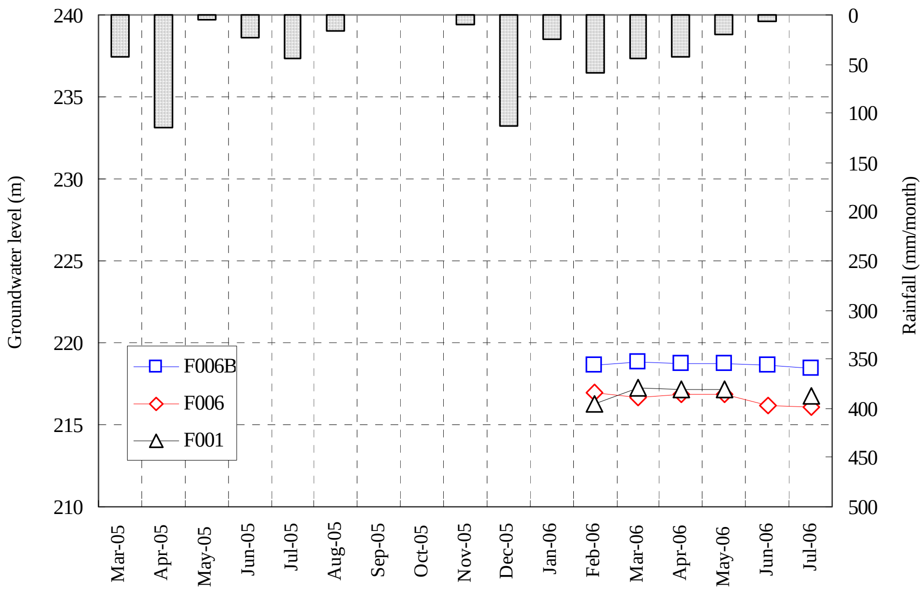


Figure 2.3.5-1 (a) Groundwater level fluctuation (Test Wells in Antanimora area)

b) Middle of Ambovombe Basin

Groundwater levels of three test wells have been monitored. Except No.F009, the results show stable fluctuation of groundwater level. Sudden decrease of groundwater level on NoF009 may be caused by abstraction from the well.

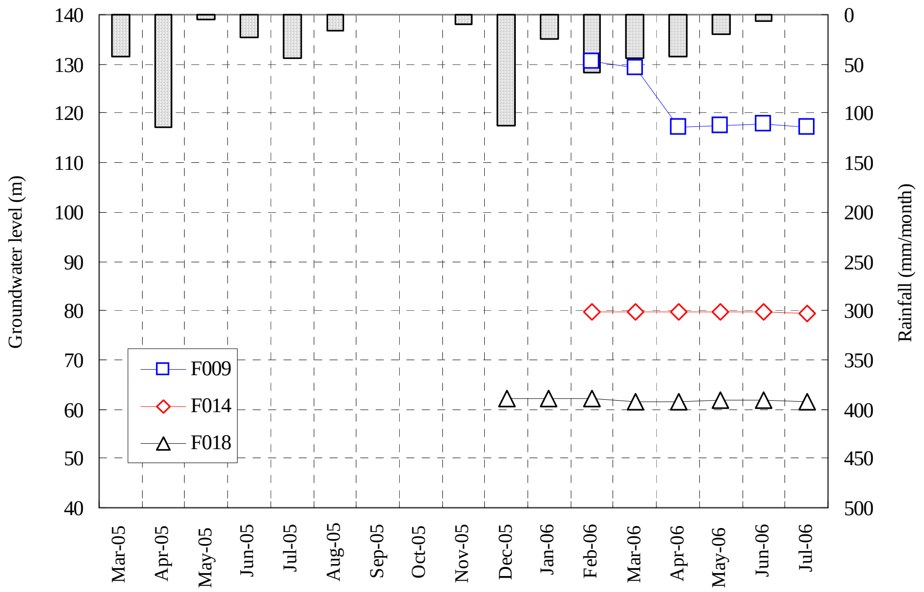


Figure 2.3.5-1 (b) Groundwater level fluctuation (Test Wells in Ambovombe area)

c) Coastal area

Groundwater levels of four test wells have been monitored. The results show gradual decreasing of groundwater level from April to July, 2006 for the well FM001 and F022. This may be caused by decrease of precipitation.

On the other hands groundwater level of the well F015 and F030 seems stable (except the sudden decreasing in July, 2006 on he well F030).

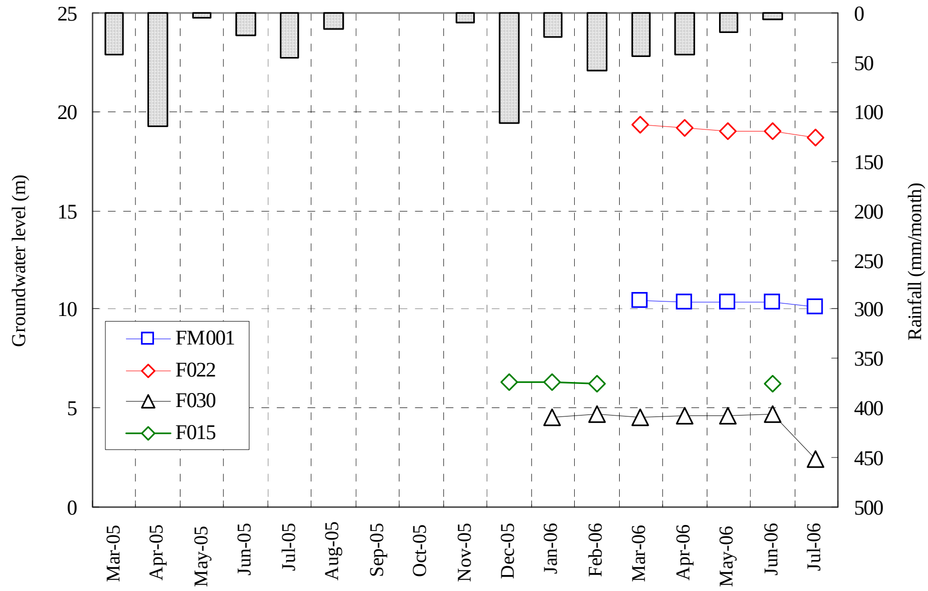


Figure 2.3.5-1 (c) Groundwater level fluctuation (Test Wells in Coastal area)

d) Shallow wells around Ambovombe city

Groundwater levels of six test wells have been monitored. Except NE-1, the results show stable groundwater level fluctuation. The uprising of groundwater level on NE-1 well may be caused by infiltration to the well.

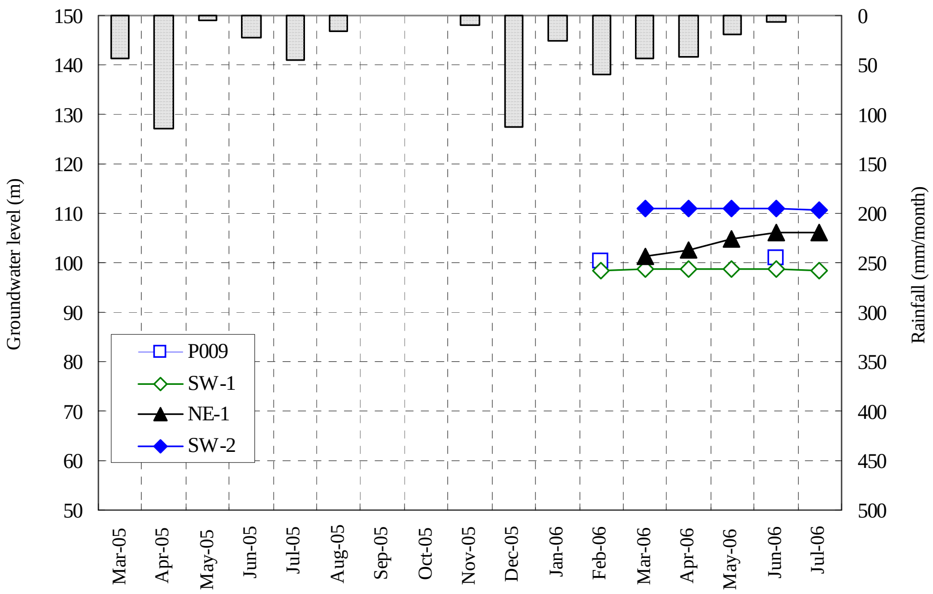


Figure 2.3.5-1 (d) Groundwater level fluctuation (Test Wells in Ambovombe city)

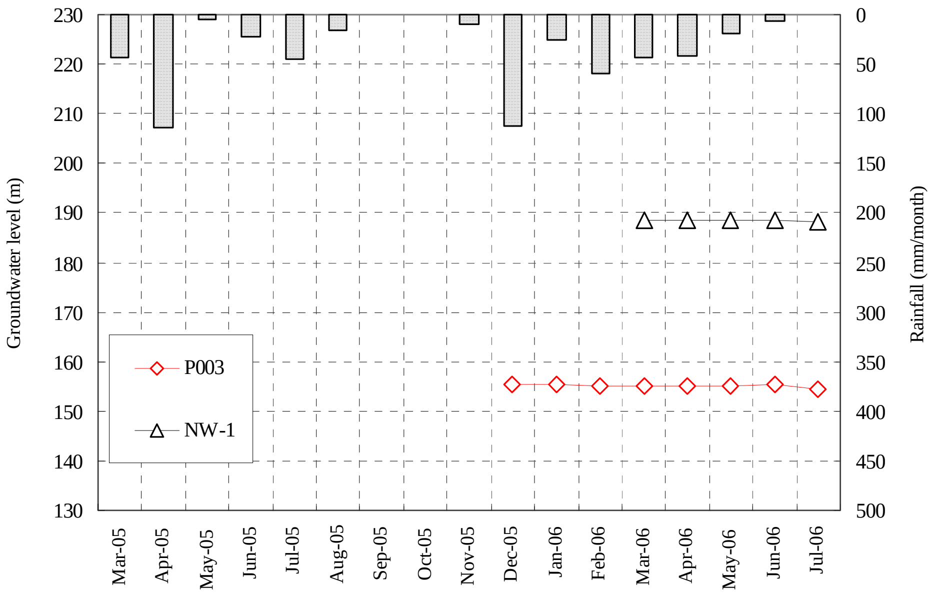


Figure 2.3.5-1 (e) Groundwater level fluctuation (Test Wells in Antanimora area)

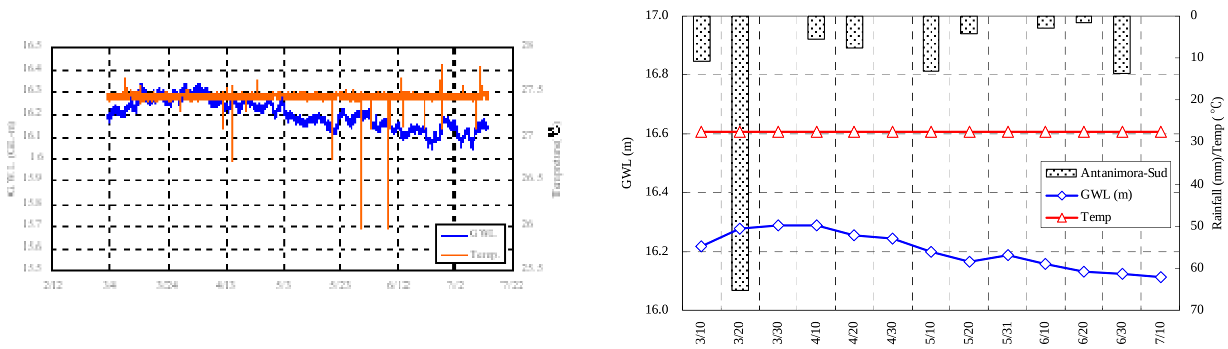
(2) Results of Automatic Groundwater Level Gauge

Figure 2.3.5-2 shows results of groundwater level monitoring with automatic gauge. Due to inappropriate installation, sufficient data could not be obtained from the well No.F018.

Because the rainfall data is obtained only every 10 days total amount, average of 10 days groundwater level fluctuation data is prepared to compare with fluctuation of rainfall.

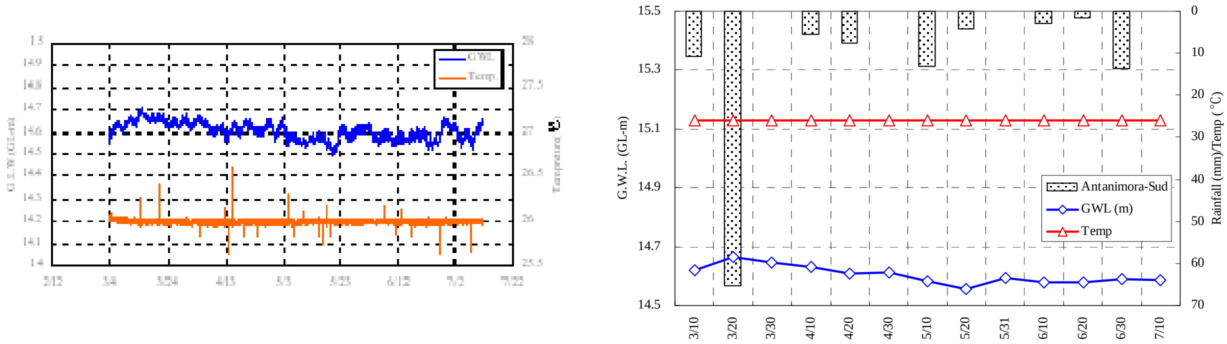
According to the Figure 2.3.5-2, basically groundwater level seems gradually decreasing from March to July, 2006 in accordance with the amount of precipitation.

Groundwater level fluctuation of the well No.F015 seems rather stable compare with the other wells.



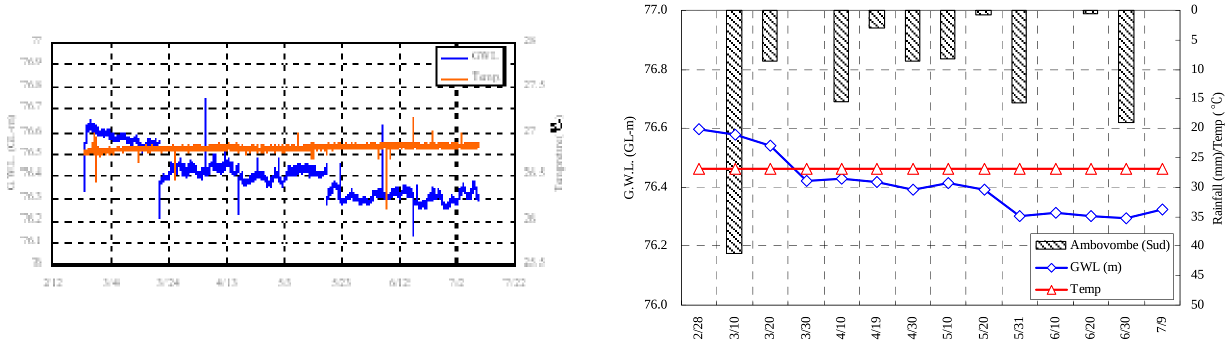
a) Original data b) 10 days average data

Figure 2.3.5-2 (a) Result of groundwater level monitoring (test well No.F001)



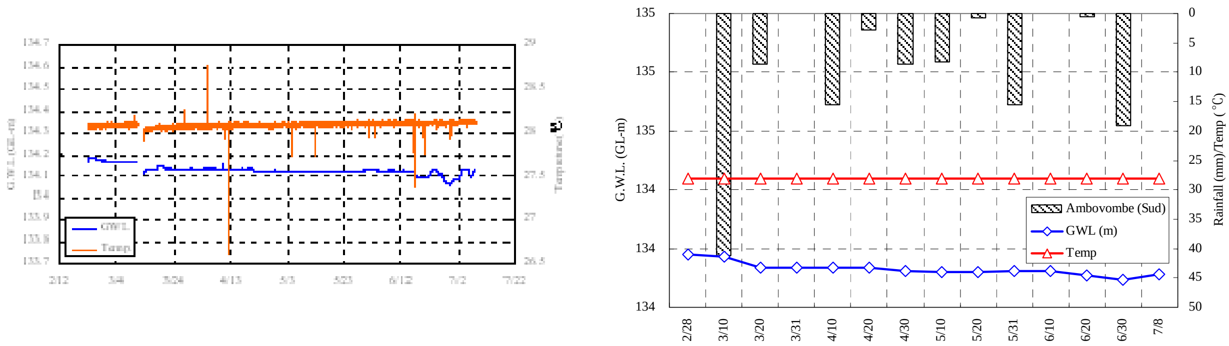
a) Original data b) 10 days average data

Figure 2.3.5-2 (b) Result of groundwater level monitoring (test well No.F006b)



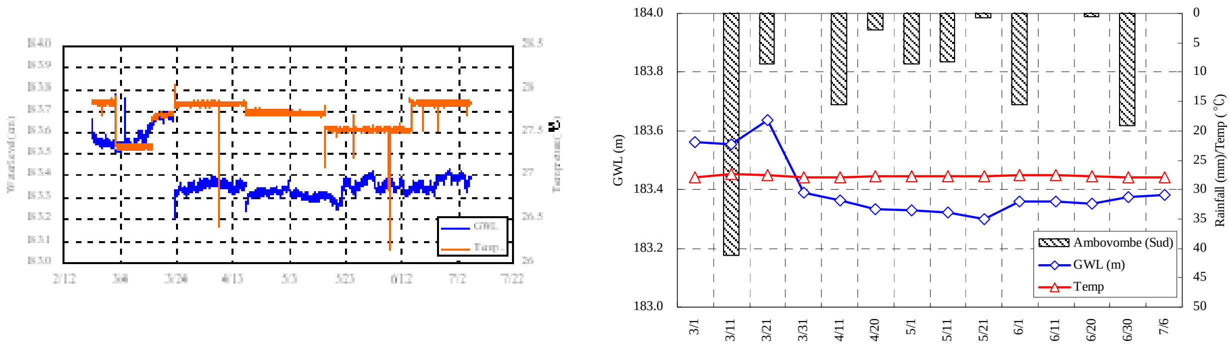
a) Original data b) 10 days average data

Figure 2.3.5-2 (c) Result of groundwater level monitoring (existing well No.604)



a) Original data b) 10 days average data

Figure 2.3.5-2 (d) Result of groundwater level monitoring (test well No.F015)



a) Original data b) 10 days average data

Figure 2.3.5-2 (e) Result of groundwater level monitoring (test well No.F030)

DP2.4 Water Quality Survey Analysis

2.4.1 Water quality survey of the wet season

(1) Sampling points

Table 2.4.1-1 (1) Characteristics of Water Quality Analysis sampling points -Shallow and Deep Wells

Type	Area	Sub-Area	Commune	Sample Name	Lat	Long	Sampling date	Well depth	Well Water level
Dug well	Ambovombe	Center	Ambovombe	001	25°10"43.8'	46°5"17.4'	25/4/2005	20.4	18.44
borehole	Ambovombe	Center	Ambovombe	604	-	-	3/5/2005	130	76.5
vovo	Ambovombe	South East	Ambovombe	010	25°10"46.3	46°5"49.9'	2/5/2005	14.15	14.5
Dug well	Ambovombe	South East	Ambovombe	277	25°10"49.3'	46°5"23.6'	2/5/2005	25.8	25.5
vovo	Ambovombe	East South East	Ambovombe	500	25°10"50.9'	46°6"1.1'	2/5/2005	18.6	18.25
vovo	Ambovombe	East South East	Ambovombe	510	25°10"56.1'	46°5"52.9'	2/5/2005	14.7	14
vovo	Ambovombe	East South East	Ambovombe	514	25°11"00.7	46°5"47.3'	2/5/2005	12.9	12.8
Dug well	Ambovombe	South	Ambovombe	276	25°10"55.5'	46°5"13.2'	2/5/2005	16.4	16.2
Dug well	Ambovombe	South	Ambovombe	132	25°11"10.5'	46°5"20.2'	2/5/2005	26.93	23.5
Dug well	Ambovombe	South	Ambovombe	124	25°11"27.3'	46°5"10.0'	2/5/2005	13.35	13.35
Dug well	Ambovombe	South South West	Ambovombe	007	25°11"7.9'	46°4"47'	25/4/2005	13.51	13.36
vovo	Ambovombe	South South West	Ambovombe	123	25°11"20.3'	46°4"39.4'	25/4/2005	12.8	13.15
vovo	Ambovombe	South-West	Ambovombe	008	25°10"56.9'	46°4"39.9'	25/4/2005	11.8	11.6
Dug well	Ambovombe	West	Ambovombe	122	25°10"45.6'	46°4"28.8'	25/4/2005	2.4	18.43
vovo	Ambovombe	North West	Ambovombe	005	25°10"21.0'	46°4"58.0'	2/5/2005	13.1	13.15
borehole	Ambovombe	North	Ambovombe	003	25°10"25.6'	46°5"12.5'	2/5/2005	22.6	17.46
vovo	Ambovombe	North East	Ambovombe	283	25°10"16.7'	46°5"34.3'	2/5/2005	7.8	7.36
vovo	Ambovombe	North East	Ambovombe	284	25°10"26.7'	46°5"33.9'	2/5/2005	8.2	7.92
borehole	Antanimora	Center	Antanimora	020	24°48'47.5"	45°39'45.1"	5/5/2005	78	5.63
borehole	Antanimora	Center	Antanimora	022	24°48'38.4"	45°40'50.3	4/5/2005	13.5	7.1
borehole	Antanimora	Center	Antanimora	140	24°48'52.5"	45°39'5.2"	5/5/2005	15.65	4.33
borehole	Antanimora	Center	Antanimora	097	24°42'58.4"	45°39'8.4"	5/5/2005	14.33	3.66
borehole	Antanimora	East-South East	Antanimora	148	24°50'25.3"	45°44'26.11"	4/5/2005	20.85	5.82
borehole	Antanimora	East-South East	Antanimora	026	24°49'0.5"	45°44'13.2"	4/5/2005	42.39	9.16
borehole	Antanimora	East-South East	Ambohimalaza	152	24°53'59"	45°52'21"	4/5/2005	42	25.35
borehole	Antanimora	South East	Antanimora	016	24°56'31.6"	45°45'48.8"	4/5/2005	29.4	7.23
borehole	Antanimora	South East	Antanimora	015	24°59'31"	45°48'00"	4/5/2005	26.5	7.85
borehole	Antanimora	South	Antanimora	121	24°53'55.0"	45°40'29.5"	4/5/2005	imp	imp
borehole	Antanimora	South	Antanimora	128	24°58'18.9"	45°41'33.7"	5/5/2005	48	23.55
borehole	Antanimora	West	Jafaro	088	24°48'58.7"	45°34'49.4"	5/5/2005	12.68	5.6
borehole	Antanimora	West	Antanimora	143	24°51'36.2"	45°33'56.2"	5/5/2005	24.3	8.16
Dug well	Ambondro		Ambondro	203	24°12'46.1"	45°48'37.7"	6/5/2005	10.21	5.42
Dug well	Ambondro		Ambondro	301	24°11'15.7"	45°47'3.11"	6/5/2005	imp	imp
Dug well	Ambondro		Sihanamaro	228	24°13'59.3"	45°47'52.1"	6/5/2005	5.67	2.41
vovo	Coastal		Maloalomainty	237	25°13"29.2'	46°11"49.2'	3/5/2005	0	0
Dug well	Coastal		Ambazoa	224	25°20"39.3'	45°54"56.6'	3/5/2005	4.94	4.77
Dug well	Coastal		Antaritarika	216	25°26"39.4'	45°42"36.4'	3/5/2005	8.18	5.34
Dug well	Ifotaka		Ifotaka	266	24°48'4.1"	45°8'10.6"	7/5/2005	9.36	7.23
Dug well	Tsihombe		Tsihombe	JIRAMA T	24°19'8.1"	45°29'2.0	6/5/2005	n.d	n.d
Dug well	Amboasary		Amboasary	JIRAMA A	25°1'58.3"	46°22'40.8"	7/5/2005	n.d	n.d

Table 2.4.1-1 (2) Characteristics of Water Quality Analysis sampling points -Others

Type	Area	Sub-Area	Commune	Sample Name	Lat	Long	Sampling date
Rainwater tank	Ambovombe	South	Ambovombe	Imp. X	25°10"57.1'	46°5"22.5'	2/5/2005
Impluvium	Coastal		Maloalomainty	Imp. Y	25°11"29.0'	46°11"31.6'	3/5/2005
Impluvium	Coastal		Ambovombe	Imp. Z	25°13"52.7'	46°6"57.6'	3/5/2005
Lake	Ambovombe		Ambovombe	Luc	25°5'35.3"	46°00'13.7"	4/5/2005
Damp	Ambovombe	West-North West	Ambovombe	Pond A	25°10"26.4'	46°4"44.7'	2/5/2005
Damp	Antanimora		Antanimora	Pond B	25°0'73.6"	45°49'25.7'	4/5/2005
River	Antanimora		Antanimora	Riv. M	24°48'55.2"	45°40'27.7"	5/5/2005
River	Antanimora		Antanimora	Riv. N	24°44'28.4"	45°44'5.2"	5/5/2005
River	Tsihombe		Tsihombe	Riv. O	24°19'0.3"	45°28'42.2"	6/5/2005
River	Amboasary		Amboasary	Riv. P	25°2'5.8"	46°22'14.0"	7/5/2005

Photo 2.4.1-1 Well 121 (Antanimora)

Photo 2.4.1-2 Well 122 (Ambovombe)

Photo 2.4.1-3 Implivium Y (Maloalomainty)

Photo 2.4.1-4 Manavovo River (Tsihombe)

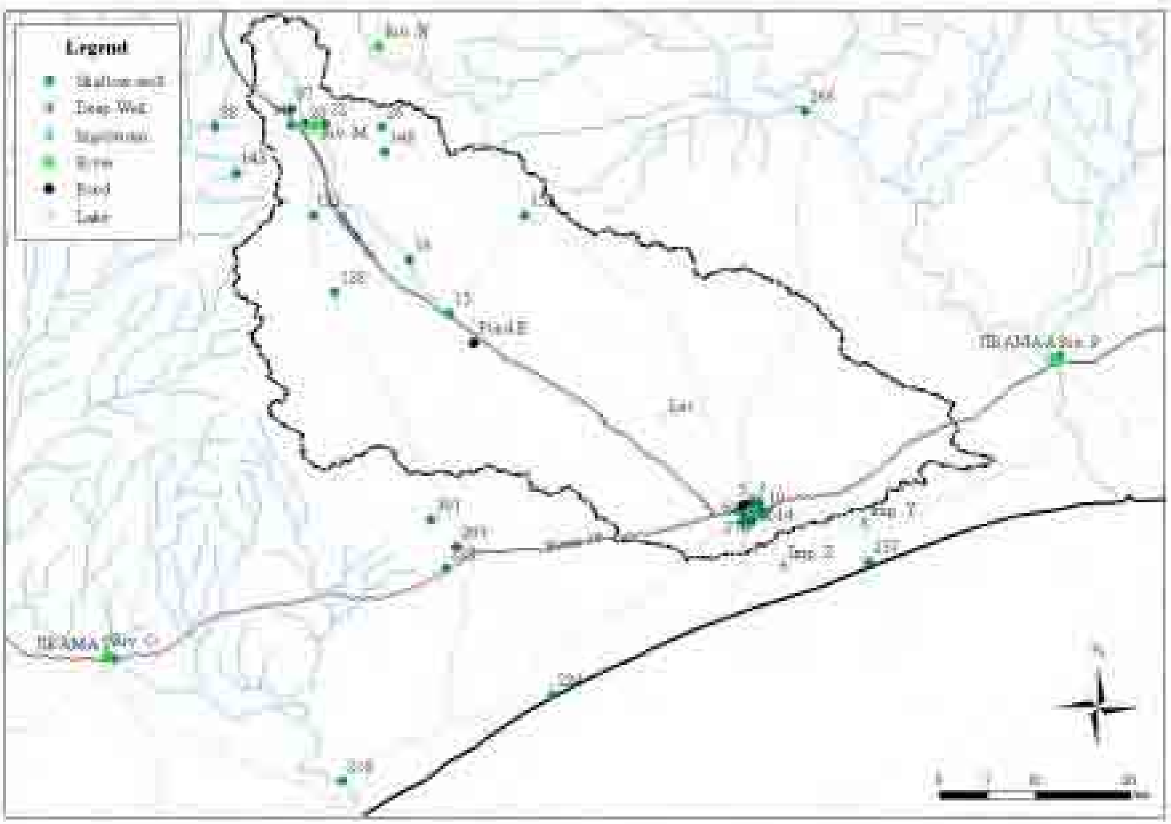


Fig.2.4.2-1(1) Water quality sampling points

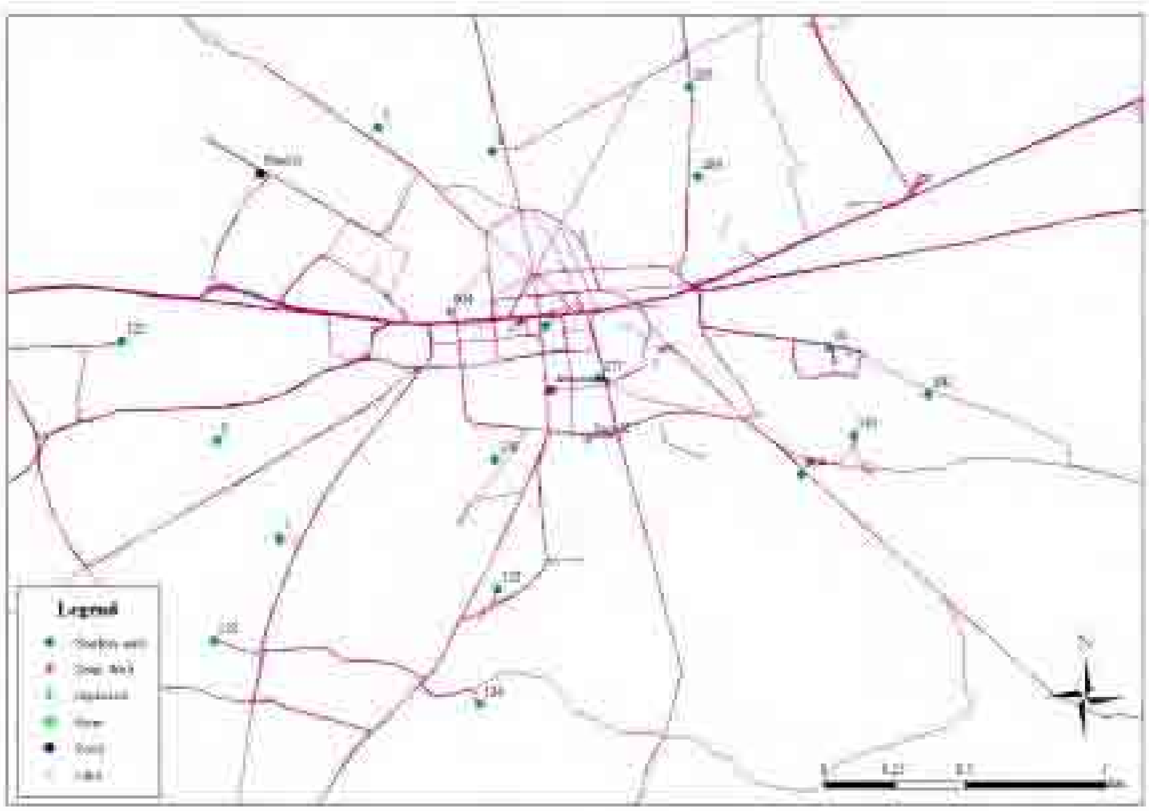


Fig. 2.4.2-1 (2) Sampling points in Ambovombe Area

(2) Results of the wet season survey

The results of the water quality analysis are shown in tables 2.4.1-2 (1-1), (1-2), (2-1), (2-2), (3-1) and (3-2).

(1) Evaluation as drinking water

1) Basic Factors (pH, EC, Odor, Taste, Color, Turbidity)

The samples from the dug wells and deep wells showed pH in the range of 7 to 8.5, in the neutral to little alkali range. The samples of *implivium* (rainwater tanks), ponds, and rivers showed rather high pH, although all but one (Pond B in Antanimora) were in the range of the Madagascar Standard.

For EC, as have been stated in section 5.1 Well Inventory, as well as past reports, the Ambovombe area is highlighted with the groundwater EC being extremely high. Water Quality Analysis results showed the same, with 11 out of 18 well samples had EC exceeding the Madagascar Standard of 300mS/m (=3,000 μS/cm). However, in the south eastern areas, dug wells (*vovo*s) had relatively low EC. In the Antanimora region, the EC showed lower values. However, as the wells situate closer to the Ambovombe area, the EC rises, and the well 015 and well 128 being the closest to Ambovombe exceeded the Madagascar standard. EC in the other region generally showed high values, mostly exceeding the Madagascar standard, especially in the coastal areas where they receive direct effects from seawater. EC in other types of water showed low conductivity.

Most of the groundwater samples detected little odor, although wells 122 in Ambovombe and 152 in Antanimora had rotten odor. These wells were not in use. Other samples had little smell except ponds, which had clayish like smell.

11 out of 18 wells in Ambovombe area had salty taste, reflecting the high salinity in the region. Most of the wells in the Antanimora region had no taste, but wells especially in the south detected salty taste. Other region, had salty taste, reflecting the high salinity. Surface water samples generally had no taste at all.

Most of the samples had no color, although some had light-yellowish color, showing possible signs of organic matter, especially in the *vovo*s in the Ambovombe region.

Turbidity of waters is mainly caused by clay, silt, colloidal particles, plankton, etc. The consumption of high turbid water may constitute a health risk, because excessive turbidity can protect pathogenic microorganisms from the effects of disinfectants and stimulate the growth of bacteria in distribution systems. The WHO recommends 5NTU as the maximum turbidity. Analysis results show that high turbidity was observed in the surface waters, especially ponds and lakes. Also, wells in the Ambovombe area had high turbidity, most exceeding the WHO guideline. These were either open-dug *vovo*s or wells not in use.

2) Bacteria

The most common and widespread health risk associated with drinking-water is contamination by human or animal excreta. *Esxherichia coli* is used here as an indicator of contamination. These are abundant in human and animal faeces, found in all natural waters and soils subject to recent faecal contamination, whether from humans or animals. WHO guideline and the Madagascar standard require no trace of Esch. coli in the drinking water.

In almost all of the samples collected had signs of bacteria (standard plate count bacteria), along with Esch, coli. Therefore, the water (both surface and groundwater) sampled are not actually suitable for drinking, and it needs at least boiling before drinking.

3) Nitrogen Compounds (Nitrate, Nitrite, Ammonia)

Nitrogen in water is mostly supplied through the biological cycle, and in groundwater it is usually caused by the decomposition of biomass by bacteria. Human activities also affect the nitrogen cycle, mostly through fertilizers and also from the combustion of fossil fuels.

Nitrate ion (NO_3^-) is the stable form of nitrogen. Its toxicity to human is thought to be solely the consequence of its reduction to nitrite. The nitrite ion (NO_2^-) in the environment is rather unstable, and with the existence of oxygen it easily oxidizes to nitrate. Nitrite involves in the oxidation of heamoglobin to methaemoglobin, which is unable to transport oxygen to the tissues. High concentration of methaemoglobin causes methaemoglobinaemia, which when serious is fatal, especially to infants.

Nitrate ion analysis results showed that there were considerable concentration of Nitrates in most of the samples, but only one well, in North Ambovombe exceeded the guideline and standard value.

Nitrite ion analysis results showed low concentration, meaning that the wells are in aerobic condition. However, there were few that exceeded the Madagascar standard, especially high in Northern Ambovombe, where one of the wells exceeded the WHO guideline value which is 30 times higher than the Madagascar standard.

Ammonia (NH_4^+) is emerged through the decomposition of protein, and in an aerobic environment is oxidized to Nitrite and eventually to Nitrate. It is not a direct importance for health only if the intake becomes severely high.

Ammonium ion analysis results showed that there were few samples that were detected, and even in those cases it did not exceed the standard given.

4) Heavy Metals (Iron, Manganese, Arsenic), Boron and Fluoride

Iron (Fe) is an abundant metal in earth crust. In anaerobic conditions, it exists as Fe^{2+} ion, and it oxidizes to Fe^{3+} ion when it reacts with oxygen. It is an essential element in human nutrition, although heavy intake may cause some problems. The analysis result shows that dug wells in the Ambovombe area has some iron content, with some exceeding the WHO standard, distributing mainly in the South western area. Dug wells in the Antanimora area mainly had little iron content, except for well no.152 in Sakave, which exceeded way over the guideline value and Madagascar standard. No iron was observed in the other areas, as well as implivium and rivers, but pond and lake near Ambovombe had iron concentration exceeding the standard.

Manganese (Mn) is also spread widely in earth crust. It can be adsorbed onto soil to an extent depending on the organic content and cation exchange capacity. By oral route, manganese is often regarded as one of the least toxic elements, although there are some epidemical reports showing some effects when taken heavily through drinking water. The analysis result shows that there was no Manganese content in any of the samples.

Arsenic (As) is sometimes found in volcanic groundwater. It is considered highly toxic when inhaled, and there are many reports of intoxication from contaminated waters. The analysis result shows that there was no Arsenic content in any of the samples.

Boron (B) is found in several types of rocks. When taken heavily inside the body, it causes boron poisoning, which has symptoms of gastrointestinal disturbances, skin eruptions, etc. The analysis results revealed no content of Boron in the samples taken.

Fluoride (F) is mainly originates from geological formation, and when taken heavily can have serious effects on skeleton tissues. According to the analysis results, there were some traces of Fluoride especially in dug wells in Antanimrora, but all were below the standard value.

5) Other Ions (Sodium, Potassium, Calcium, Magnesium, Chloride, Sulfate, Bicarbonate)

Sodium (Na) is found in rocks, rainwater and is especially abundant in seawater. It is an essential to human nutrition; however, overdoses of sodium chloride have been reported to cause acute effects and death. The WHO sets 200mg/L as maximum concentration in the drinking water, although Madagascar has no standard for sodium. Dug well analysis results in the area revealed that there was extremely high concentration for sodium, especially in the Ambovombe area. In the Ambovombe area almost all of the samples except the east-south-eastern areas exceeded the WHO standard. Dug wells in the Antanimora, Ambondro, Coastal Areas also observed high values, and most of them were over the standard. Impliviums and surface waters were low however, except for Manavovo River.

Potassium (K) exists inside the earth crust mainly in the form of Silica salt (rocks) and seawater. There are no reports for its toxicity, and there are no standard values in both in the WHO guidelines and the Madagascar standard. Potassium concentration in the samples collected from the dug wells was relatively high in Ambovombe, Southern Antanimora area, Ambondro and Coastal regions, also relatively high in Ponds and lake.

Calcium (Ca) widely exists in the earth crust in forms of Silica salt, Carbonate salt and Sulfate salt. It is an essential to human nutrition; however, heavy intake causes health problems. Currently, the WHO has not set a standard, but Madagascar has set 200mg/L as maximum concentration in the drinking water. Calcium concentration in the samples of the dug wells was generally low, although some of the samples especially in Ambovombe area exceeded the national standard, with the highest being the deep well in Central Ambovombe (well no.604).

Magnesium (Mg) is also found in the earth crust in forms of Silica salt, and is also contained in seawater. It is also an essential to the human nutrition, and there is no WHO standard, although Madagascar sets 50mg/L as the maximum in drinking water. The analysis results showed that high concentration of Magnesium was observed in shallow and deep wells of central to northern Ambovombe, southern Antanimora area, Ambondro, Coastal area as well as Manavovo River. These exceeded the Madagascar standard.

Chloride (Cl^-) is an abundant substance in water bodies, and its origin is mostly from seawater. It is essential to human nutrition, but heavy intake causes in some cases sodium chloride metabolism. The WHO recommends 250mg/L as maximum concentration in drinking water, same as the standard in Madagascar. The dug well waters in the area, as a result of the analysis, showed that the waters had extremely high concentration of Chloride, especially in Ambovombe (Except east south eastern area), southern Antanimora, Ambondro, Coastal area and Manavovo River, most of them exceeding the WHO guideline and Madagascar standard values.

Sulfate (SO_4^{2-}) can be found in water originating from many forms, such as rocks, seawater and rain. Its toxicity is very low, but WHO has set 250mg/L as guideline value. Analysis results show that Sulfate concentration is high in dug wells of western Ambovombe, south to western Antanimora and both dug wells owned by JI.RA.MA in Tsihombe and Amboasary, as well as Manavovo River.

Bicarbonate is one of the ionic forms of Carbon Dioxide in waters, and is intoxicative to humans. The dug well waters in the region are rich in Bicarbonate, especially in Antanimora region.

Table 2.4.1-2 (1-1) Water Quality Analysis Results - Filed Survey, Shallow and Deep Wells

Type	Area	Sub-Area	Commune	Sample	Results												
						Temp.	Odor	Taste	Color	pH	EC	DO	M-Alkality	CO2	Boron	E. Coli	Bacteria
						℃					mS/m	mg/L	mg/L	mg/L	mg/L	numb/mL	numb/mL
					WHO Std.										*0.3*	*0*	
					Madag. Std					*6.5-9*	*300*					*0*	
Dug well	Ambovombe	Center	Ambovombe	001		27	None	None	None	7.2	**580**	4.4	165	20	0	**6**	**5**
borehole	Ambovombe	Center	Ambovombe	604		24	None	Salty	None	7.35	**730**	6.5	21	2	0	**4**	**5**
vovo	Ambovombe	South East	Ambovombe	010		25	None	None	Light Yellowish	7.8	148	4.3	140	4	0	**36**	**60**
Dug well	Ambovombe	South East	Ambovombe	ff7		26	None	Slight Salty	None	7.7	**353**	2.3	105	4	0	**24**	**39**
vovo	Ambovombe	East South East	Ambovombe	500		26	None	Slight Salty	Whitish	8.1	105	4.3	150	2	0	**1**	**1**
vovo	Ambovombe	East South East	Ambovombe	510		25	None	None	Light Yellowish	8.5	54	5.2	95	1	0	**13**	**128**
vovo	Ambovombe	East South East	Ambovombe	514		24	None	None	Light Yellowish	7.8	74	3.5	70	2	0	**200**	**100**
Dug well	Ambovombe	South	Ambovombe	276		26	None	Slight Salty	None	7.7	**450**	5.4	200	8	0	**75**	**80**
Dug well	Ambovombe	South	Ambovombe	132		25	None	Slight Salty	None	7.8	**328**	5.3	295	9	0	**1**	**56**
Dug well	Ambovombe	South	Ambovombe	124		26	None	None	Light Yellowish	7.9	174	4	330	8	0	**56**	**22**
Dug well	Ambovombe	South South West	Ambovombe	007		26	None	Slight Salty	Brownish	7.4	269	3.8	355	27	0	**64**	**200**
vovo	Ambovombe	South South West	Ambovombe	123		26	Clayish	Slight Salty	Reddish Brown	8	**1572**	4.4	25	0	0	**9**	**10**
vovo	Ambovombe	South-West	Ambovombe	008		25	None	None	Grayish	8.3	225	6.8	420	4	0	**60**	**21**
Dug well	Ambovombe	West	Ambovombe	122		27	Rotten	Salty	Brownish	7.6	**1412**	2.2	720	35	0	**200**	**15**
vovo	Ambovombe	North West	Ambovombe	005		24	Clayish	None	Brownish-White	7.4	**399**	3.7	75	6	0	**1**	**3**
borehole	Ambovombe	North	Ambovombe	003		26	None	Salty	Whitish	7.3	**941**	5.5	330	32	0	**36**	**40**
vovo	Ambovombe	North East	Ambovombe	283		26	None	Slight Salty	None	8	**483**	3.4	240	5	0	**4**	**12**
vovo	Ambovombe	North East	Ambovombe	284		25	None	Slight Salty	None	8.2	218	7.5	380	5	0	**200**	**4**
borehole	Antanimora	Center	Antanimora	020		24	None	None	None	7.6	142	2.4	575	28	0	**15**	0
borehole	Antanimora	Center	Antanimora	022		26	None	None	None	7.3	176	6	588	57	0	0	**150**
borehole	Antanimora	Center	Antanimora	140		27	None	None	None	7.9	67	4.7	281	7	0	**34**	0
borehole	Antanimora	Center	Antanimora	097		25	None	Slight Salty	None	7.9	139	3.2	578	14	0	**12**	**3**
borehole	Antanimora	East-South East	Antanimora	148		27	None	None	None	7.3	189	4.2	243	24	0	**15**	**10**
borehole	Antanimora	East-South East	Antanimora	026		27	None	None	None	7	70	3.1	206	40	0	**30**	**31**
borehole	Antanimora	East-South East	Ambohimalaza	152		28	Rotten	Slight Salty	Light Yellowish	7.4	242	2.3	287	22	0	**31**	**33**
borehole	Antanimora	South East	Antanimora	016		27	None	None	None	7.3	167	4	551	54	0	**7**	**80**
borehole	Antanimora	South East	Antanimora	015		26	None	Slight Salty	None	7.6	**388**	2.8	262	13	0	0	**16**
borehole	Antanimora	South	Antanimora	121		28	None	Bitter	None	7.8	150	4.9	448	14	0	**20**	**12**
borehole	Antanimora	South	Antanimora	128		27	None	Salty	None	7.1	**609**	2.4	661	102	0	**1**	**9**
borehole	Antanimora	West	Jafaro	088		26	None	None	None	8.1	184	2.9	825	13	0	**98**	**9**
borehole	Antanimora	West	Antanimora	143		27	None	Slight Salty	None	8.1	144	4.1	580	9	0	**72**	**3**
Dug well	Ambondro	-	Ambondro	203		26	None	Slight Salty	None	7.5	211	5.3	109	7	0	**26**	**10**
Dug well	Ambondro	-	Ambondro	301		24	None	Salty	Yellow	7.9	**2400**	4.1	645	16	0	**141**	**12**

Type	Area	Sub-Area	Commune	Sample	Results												
						Temp.	**Odor**	**Taste**	**Color**	**pH**	**EC**	**DO**	**M-Alkality**	**CO2**	**Boron**	**E. Coli**	**Bacteria**
						℃					**mS/m**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**numb/mL**	**numb/mL**
					WHO Std.										*0.3*	*0*	
					Madag. Std					*6.5-9*	*300*					*0*	
Dug well	Ambondro	-	Sihanamaro	228		25	None	None	None	7.6	168	2.3	201	10	0	**15**	**18**
vovo	Coastal	-	Maloalomainty	237		25	None	Salty	None	7.5	**1199**	4.5	342	21	0	**44**	**5**
Dug well	Coastal	-	Ambazoa	224		24	None	Slight Salty	None	8	**393**	4.1	226	4	0	**200**	**5**
Dug well	Coastal	-	Antaritarika	216		25	None	Slight Salty	None	7.7	256	3.9	586	23	0	**1**	**8**
Dug well	Ifotaka	-	Ifotaka	266		28	None	None	None	8.1	37	5.6	183	3	0	**200**	**200**
Dug well	Tsihombe	-	Tsihombe	JIRAMA T		27	None	Salty	None	7.2	**541**	2.4	541	66	0	**68**	**2**
Dug well	Amboasary	-	Amboasary	JIRAMA A		27	None	Slight Salty	None	7.9	231	7.1	90	2	0	**200**	**9**

Table 2.4.1-2 (1-2) Water Quality Analysis Results - Filed Survey, Others

Type	Area	Sub-Area	Commune	Sample	Results												
						Temp.	**Odor**	**Taste**	**Color**	**pH**	**EC**	**DO**	**M-Alkality**	**CO2**	**Boron**	**E. Coli**	**Bacteria**
						℃					**mS/m**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**numb/mL**	**numb/mL**
					WHO Std.										*0.3*	*0*	
					Madag. Std					*6.5-9*	*300*					*0*	
Rainwater tank	Ambovombe	South	Ambovombe	Imp. X		26	None	None	None	7.7	11	5	18	1	0	0	**10**
Impluvium	Coastal	-	Maloalomainty	Imp. Y		22	None	None	None	8.7	29	5	84	0	0	**64**	**4**
Impluvium	Coastal	-	Ambovombe	Imp. Z		24	None	None	None	7.8	17	4.4	48	1	0	**4**	**3**
Lake	Ambovombe	-	Ambovombe	luc		21	Clayish	Clayish	Grayish	7.7	30	6.5	76	3	0	**200**	**200**
Damp	Ambovombe	West-North West	Ambovombe	Pond A		23	Clayish	Clayish	Grayish	7.5	34	2.3	50	3	0	**9**	**8**
Damp	Antanimora	-	Antanimora	Pond B		23	Clayish	None	Light Yellowish	9.1	13	7.7	67	0	0	**42**	**5**
River	Antanimora	Bemamba Riv.	Antanimora	Riv. M		26	None	None	Light Yellowish	7.8	47	1.9	278	9	0	**200**	**200**
River	Antanimora	Ikonda Riv.	Antanimora	Riv. N		29	None	None	None	8.5	64	7.8	298	2	0	**2**	0
River	Tsihombe	Manavovo Riv.	Tsihombe	Riv. O		30	None	Salty	None	8.6	0.44	9	202	1	0	**119**	**17**
River	Amboasary	Mandorare Riv.	Amboasary	Riv. P		25	None	None	Light Yellowish	8.2	24	7.8	324	4	0	**200**	**200**

Note: The figures in **bold** are concentrations that are above either Madagascar, or WHO standards

Table 2.4.1-2 (2) Water Quality Analysis results - Laboratory Results (Metallic Ion)

Type	Area	Sub-Area	Commune	Sample	Results	Potassium	Sodium	Calcium	Magnesium	Iron	Manganese	Arsenic
						K	Na	Ca	Mg	Fe	Mn	As
						mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
					WHO.		*200*			*0.3*	*0.5*	*0.01*
					Madag.			*200*	*50*	*0.5*	*0.05*	*0.05*
Dug well	Ambovombe	Center	Ambovombe	001		180.90	**483.00**	**244.00**	**324.41**	0.00	0.00	0.00
borehole	Ambovombe	Center	Ambovombe	604		156.20	**785.42**	**793.60**	**635.69**	*0.45*	0.00	0.00
vovo	Ambovombe	South East	Ambovombe	010		21.25	187.11	10.40	20.90	0.25	0.00	0.00
Dug well	Ambovombe	South East	Ambovombe	277		33.05	**258.74**	99.20	38.88	0.25	0.00	0.00
vovo	Ambovombe	East South East	Ambovombe	500		18.20	77.10	14.40	15.07	**44.22**	0.00	0.00
vovo	Ambovombe	East South East	Ambovombe	510		11.94	79.18	7.20	9.96	0.15	0.00	0.00
vovo	Ambovombe	East South East	Ambovombe	514		13.55	78.35	9.20	11.18	*0.35*	0.00	0.00
Dug well	Ambovombe	South	Ambovombe	276		30.83	**604.66**	67.20	**70.47**	0.15	0.00	0.00
Dug well	Ambovombe	South	Ambovombe	132		22.85	**512.55**	97.60	**51.03**	0.01	0.00	0.00
Dug well	Ambovombe	South	Ambovombe	124		7.83	121.36	7.20	**122.96**	**0.81**	0.00	0.00
Dug well	Ambovombe	S-South West	Ambovombe	007		22.50	**512.96**	24.00	14.58	**2.80**	0.00	0.00
vovo	Ambovombe	S-South West	Ambovombe	123		11.34	**233.47**	17.60	20.90	**1.50**	0.00	0.00
vovo	Ambovombe	South-West	Ambovombe	008		44.90	**435.70**	15.20	14.09	**10.00**	0.00	0.00
Dug well	Ambovombe	West	Ambovombe	122		191.30	**2727.57**	**636.00**	**459.27**	traces	0.00	0.00
vovo	Ambovombe	North West	Ambovombe	005		43.00	**355.52**	64.00	**61.72**	**0.55**	0.00	0.00
borehole	Ambovombe	North	Ambovombe	003		67.85	**983.32**	320.00	**243.97**	0.15	0.00	0.00
vovo	Ambovombe	North East	Ambovombe	283		100.45	**269.54**	160.80	**116.64**	0.04	0.00	0.00
vovo	Ambovombe	North East	Ambovombe	284		32.25	**305.58**	36.80	31.10	*0.45*	0.00	0.00
borehole	Antanimora	Center	Antanimora	020		9.50	**202.97**	43.20	40.34	0.00	0.00	0.00
borehole	Antanimora	Center	Antanimora	022		2.28	87.54	44.80	**127.33**	0.04	0.00	0.00
borehole	Antanimora	Center	Antanimora	140		1.09	103.01	21.20	14.34	0.01	0.00	0.00
borehole	Antanimora	Center	Antanimora	097		3.62	**238.16**	24.00	30.13	0.01	0.00	0.00
borehole	Antanimora	East-South East	Antanimora	148		10.92	**292.14**	36.00	46.17	0.15	0.00	0.00
borehole	Antanimora	East-South East	Antanimora	026		18.69	58.65	13.20	8.51	0.15	0.00	0.00
borehole	Antanimora	East-South East	Ambohimalaza	152		46.90	**946.24**	56.00	**97.00**	**28.00**	0.00	0.00
borehole	Antanimora	South East	Antanimora	016		43.00	**216.23**	60.80	**76.30**	0.55	0.00	0.00
borehole	Antanimora	South East	Antanimora	015		67.85	**492.59**	56.80	**148.23**	0.15	0.00	0.00
borehole	Antanimora	South	Antanimora	121		100.45	**244.38**	18.40	47.14	0.04	0.00	0.00
borehole	Antanimora	South	Antanimora	128		17.48	**868.05**	60.00	**272.16**	0.08	0.00	0.00
borehole	Antanimora	West	Jafaro	088		0.90	**345.13**	20.00	39.37	0.04	0.00	0.00
borehole	Antanimora	West	Antanimora	143		0.45	**204.99**	22.40	35.48	0.02	0.00	0.00
Dug well	Ambondro	-	Ambondro	203		16.08	98.29	44.00	**69.01**	0.00	0.00	0.00
Dug well	Ambondro	-	Ambondro	301		2376.00	**1460.50**	720.00	**1069.20**	0.01	0.00	0.00
Dug well	Ambondro	-	Sihanamaro	228		22.60	**206.47**	61.60	25.76	0.00	0.00	0.00
vovo	Coastal	-	Maloalomainty	237		78.45	**2705.00**	**313.60**	3.89	0.00	0.00	0.00
Dug well	Coastal	-	Ambazoa	224		76.70	**363.87**	85.60	**121.99**	0.01	0.00	0.00
Dug well	Coastal	-	Antaritarika	216		12.88	**348.39**	52.00	**81.16**	0.03	0.00	0.00
Dug well	Ifotaka	-	Ifotaka	266		1.49	39.71	36.00	11.66	0.00	0.00	0.00
Dug well	Tsihombe	-	Tsihombe	JIRAMA T		67.10	**1496.88**	**209.60**	**164.03**	0.00	0.00	0.00
Dug well	Amboasary	-	Amboasary	JIRAMA A		7.32	**336.74**	76.00	**60.75**	0.01	0.00	0.00
Rainwater tank	Ambovombe	South	Ambovombe	Imp. X		1.00	1.98	6.00	1.22	0.00	0.00	0.00
Impluvium	Coastal	-	Maloalomainty	Imp. Y		9.66	4.60	28.00	2.67	0.00	0.00	0.00
Impluvium	Coastal	-	Ambovombe	Imp. Z		3.86	7.26	16.80	0.97	0.01	0.00	0.00
Lake	Ambovombe	-	Ambovombe	luc		21.50	10.34	19.20	6.08	**3.20**	0.00	0.00
Damp	Ambovombe	West-North West	Ambovombe	Pond A		46.90	20.70	12.00	12.15	**28.00**	0.00	0.00
Damp	Antanimora	-	Antanimora	Pond B		13.09	5.33	14.00	3.65	0.25	0.00	0.00
River	Antanimora	Bemamba Riv.	Antanimora	Riv. M		8.50	18.19	29.20	24.79	0.25	0.00	0.00
River	Antanimora	Ikonda Riv.	Antanimora	Riv. N		4.41	55.06	29.20	34.61	0.01	0.00	0.00
River	Tsihombe	Manavovo Riv.	Tsihombe	Riv. O		11.48	**441.59**	175.20	**138.51**	0.01	0.00	0.00
River	Amboasary	Mandorare Riv.	Amboasary	Riv. P		2.21	22.40	24.00	6.80	0.08	0.00	0.00

Note: The figures in **bold** are concentrations that are above either Madagascar, or WHO standards

Table 2.4.1-2 (3-1) Water Quality Analysis results - Laboratory Results (Others) : Shallow and Deep Wells

Type	Area	Sub-Area	Commune	Sample	Chloride	Sulfate	Bicarbonate	Nitrite	Nitrate	Ammonium	Fluoride	Turbidity	T-Hardness
					Cl	SO4	HCO3	NO2	NO3	NH4	F		
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	F
					250	*250*		*3*	*50*	*1.5*	*1.5*	*5*	
					250	*250*		*0.1*	*50*	*0.5*	*1.5*		*50*
Dug well	Ambovombe	Center	Ambovombe	001	**745.50**	**413.00**	146.40	0.00	8.77	0.02	0.00	2.70	**194.50**
borehole	Ambovombe	Center	Ambovombe	604	**4288.40**	**297.70**	214.72	**0.16**	2.21	0.06	0.52	**49.40**	**460.00**
vovo	Ambovombe	South East	Ambovombe	010	**287.55**	27.43	141.52	**0.16**	7.35	0.00	0.42	**7.27**	11.20
Dug well	Ambovombe	South East	Ambovombe	277	**429.55**	**265.94**	192.76	**2.27**	13.74	0.02	0.00	2.91	40.80
vovo	Ambovombe	East South East	Ambovombe	500	209.45	0.25	165.92	0.06	1.36	0.00	0.00	**15.50**	9.80
vovo	Ambovombe	East South East	Ambovombe	510	92.30	31.52	95.16	0.09	1.14	0.00	0.60	**13.30**	5.90
vovo	Ambovombe	East South East	Ambovombe	514	129.57	24.59	87.84	**0.15**	2.94	0.00	0.00	**21.60**	6.90
Dug well	Ambovombe	South	Ambovombe	276	**972.70**	182.44	283.04	0.09	44.34	0.00	0.59	**6.13**	**445.80**
Dug well	Ambovombe	South	Ambovombe	132	**820.05**	185.20	341.60	0.09	1.91	0.00	0.26	1.00	45.40
Dug well	Ambovombe	South	Ambovombe	124	**291.10**	158.40	309.88	0.08	7.35	0.00	0.00	**148.00**	**52.40**
Dug well	Ambovombe	South South West	Ambovombe	007	**541.35**	**263.88**	305.00	0.01	1.51	0.00	0.00	**67.60**	12.00
vovo	Ambovombe	South South West	Ambovombe	123	**280.45**	75.18	241.56	0.09	1.15	0.02	0.00	**256.00**	13.00
vovo	Ambovombe	South-West	Ambovombe	008	**443.74**	125.70	431.88	0.08	0.39	0.04	0.00	**2784.00**	9.60
Dug well	Ambovombe	West	Ambovombe	122	**4295.50**	**2761.50**	644.16	0.01	0.18	0.04	0.00	3.90	**348.00**
vovo	Ambovombe	North West	Ambovombe	005	**624.80**	256.60	145.18	**2.79**	23.75	0.00	0.00	**14.30**	41.40
borehole	Ambovombe	North	Ambovombe	003	**1846.00**	**1020.45**	409.92	**0.49**	**55.89**	0.00	0.59	3.85	**180.40**
vovo	Ambovombe	North East	Ambovombe	283	**898.15**	86.78	295.24	**3.68**	22.94	0.02	0.44	4.33	**88.20**
vovo	Ambovombe	North East	Ambovombe	284	**340.80**	115.32	414.80	0.66	4.99	0.00	0.34	**15.90**	22.00
borehole	Antanimora	Center	Antanimora	020	139.16	123.15	519.72	0.00	0.04	0.02	0.00	**44.30**	27.40
borehole	Antanimora	Center	Antanimora	022	173.95	4.65	734.44	0.00	0.39	0.04	0.19	1.80	**63.60**
borehole	Antanimora	Center	Antanimora	140	40.82	15.02	328.18	0.03	0.85	0.00	0.39	0.82	11.20
borehole	Antanimora	Center	Antanimora	097	117.15	56.72	585.60	0.03	3.53	0.02	0.59	0.78	18.40
borehole	Antanimora	East-South East	Antanimora	148	**347.90**	164.02	326.96	0.06	2.21	0.08	0.68	1.29	28.00
borehole	Antanimora	East-South East	Antanimora	026	90.52	73.96	307.44	**0.10**	2.90	0.00	0.39	1.55	6.80
borehole	Antanimora	East-South East	Ambohimalaza	152	**972.70**	**589.61**	756.40	**0.43**	0.02	0.02	0.63	**52.80**	**50.20**
borehole	Antanimora	South East	Antanimora	016	234.30	**257.89**	444.08	**0.13**	0.43	0.02	0.49	**13.70**	**46.60**
borehole	Antanimora	South East	Antanimora	015	**1086.30**	40.47	378.20	0.06	0.07	0.04	0.24	**5.15**	**75.20**
borehole	Antanimora	South	Antanimora	121	166.85	73.35	575.84	0.06	0.21	0.02	0.53	2.09	24.00
borehole	Antanimora	South	Antanimora	128	**1391.60**	**686.35**	668.56	0.06	2.06	0.00	0.00	3.18	**127.00**
borehole	Antanimora	West	Jafaro	088	149.10	54.01	858.88	**1.35**	4.12	0.00	0.57	0.84	21.20
borehole	Antanimora	West	Antanimora	143	177.50	64.20	517.28	0.06	5.12	0.00	0.00	2.77	20.20
Dug well	Ambondro	-	Ambondro	203	**383.40**	2.26	131.76	0.06	12.65	0.06	0.00	2.04	39.40
Dug well	Ambondro	-	Ambondro	301	**2254.25**	**1196.00**	849.12	**1.78**	42.64	0.06	0.71	2.98	**620.00**
Dug well	Ambondro	-	Sihanamaro	228	**294.65**	127.55	253.76	**2.43**	1.76	0.04	0.26	2.05	26.00
vovo	Coastal	-	Maloalomainty	237	**4174.80**	**1972.00**	366.00	0.09	3.82	0.08	0.63	3.41	**80.00**

Type	Area	Sub-Area	Commune	Sample	Chloride	Sulfate	Bicarbonate	Nitrite	Nitrate	Ammonium	Fluoride	Turbidity	T-Hardness
					Cl	SO4	HCO3	NO2	NO3	NH4	F		
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	F
					250	*250*		*3*	*50*	*1.5*	*1.5*	*5*	
					250	*250*		*0.1*	*50*	*0.5*	*1.5*		*50*
Dug well	Coastal	-	Ambazoa	224	**983.35**	47.24	222.04	**0.33**	4.18	0.02	0.61	1.28	**71.60**
Dug well	Coastal	-	Antaritarika	216	**433.10**	162.72	580.72	**1.45**	3.02	0.02	0.47	2.25	46.40
Dug well	Ifotaka	-	Ifotaka	266	17.75	13.66	239.12	0.01	3.17	0.02	0.27	1.33	13.80
Dug well	Tsihombe	-	Tsihombe	JIRAMA T	**1956.05**	**1146.60**	712.48	**1.48**	46.11	0.02	0.24	1.83	**119.90**
Dug well	Amboasary	-	Amboasary	JIRAMA A	**493.45**	133.70	444.08	0.00	0.36	0.04	0.46	1.83	44.00

Table 2.4.1-2 (3-2) Water Quality Analysis results - Laboratory Results (Others) : others

Type	Area	Sub-Area	Commune	Sample	Chloride	Sulfate	Bicarbonate	Nitrite	Nitrate	Ammonium	Fluoride	Turbidity	T-Hardness
					Cl	SO4	HCO3	NO2	NO3	NH4	F		
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	F
					250	*250*		*3*	*50*	*1.5*	*1.5*	*5*	
					250	*250*		*0.1*	*50*	*0.5*	*1.5*		
Rainwater tank	Ambovombe	South	Ambovombe	Imp. X	7.10	0.53	24.40	0.00	0.05	0.00	0.00	1.79	2.00
Impluvium	Coastal	-	Maloalomainty	Imp. Y	7.10	3.37	95.16	0.02	0.07	0.00	0.64	2.04	8.10
Impluvium	Coastal	-	Ambovombe	Imp. Z	10.65	0.39	50.02	**0.21**	0.15	0.00	0.00	1.58	4.60
Lake	Ambovombe	-	Ambovombe	luc	17.75	0.00	101.26	0.00	0.21	0.02	0.67	774.00	7.30
Damp	Ambovombe	West-North West	Ambovombe	Pond A	31.95	125.19	65.88	**0.18**	0.12	0.06	0.10	3686.00	8.00
Damp	Antanimora	-	Antanimora	Pond B	5.32	0.57	71.98	0.00	0.00	0.02	0.04	33.50	5.00
River	Antanimora	Bemamba Riv.	Antanimora	Riv. M	28.40	11.78	239.12	**1.84**	1.03	0.00	0.00	4.75	17.50
River	Antanimora	Ikonda Riv.	Antanimora	Riv. N	53.25	16.10	296.45	0.01	0.12	0.00	0.61	10.30	21.50
River	Tsihombe	Manavovo Riv.	Tsihombe	Riv. O	**947.85**	**406.42**	236.88	0.06	6.24	0.08	0.61	10.20	100.80
River	Amboasary	Mandorare Riv.	Amboasary	Riv. P	23.08	5.55	126.88	0.00	0.02	0.02	0.15	62.00	8.80

Note: The figures in **bold** are concentrations that are above either Madagascar, or WHO standards

2.4.2 Water quality survey of the dry season

(1) Sampling points

Table 2.4.2-1 (1) Characteristics of Water Quality Analysis sampling points -Shallow and Deep Wells

Type	Area	Sub-Area	Commune	Sample Name	Lat	Long	Sampling date	Well depth	Well Water level
Dug Well	Amvobombe	Center	Amvobombe	001	25°10"43.8'	46°5"17.4'	21/9/2005	20.4	18.44
DeepWell	Amvobombe	Center	Amvobombe	604	0	0	21/9/2005	130	76.5
Dug Well	Amvobombe	South East	Amvobombe	010	25°10"46.3	46°5"49.9'	21/9/2005	14.15	14.5
Dug Well	Amvobombe	South East	Amvobombe	277	25°10"49.3'	46°5"23.6'	21/9/2005	25.8	25.5
Dug Well	Amvobombe	East South East	Amvobombe	500	25°10"50.9'	46°6"1.1'	21/9/2005	18.6	18.25
Dug Well	Amvobombe	East South East	Amvobombe	510	25°10"56.1'	46°5"52.9'	21/9/2005	14.7	14
Dug Well	Amvobombe	East South East	Amvobombe	514	25°11"00.7	46°5"47.3'	21/9/2005	12.9	12.8
Dug Well	Amvobombe	South	Amvobombe	276	25°10"55.5'	46°5"13.2'	21/9/2005	16.4	16.2
Dug Well	Amvobombe	South	Amvobombe	134	25°11"10.5'	46°5"20.2'	21/9/2005	26.93	23.5
Dug Well	Amvobombe	South	Amvobombe	124	25°11"27.3'	46°5"10.0'	21/9/2005	13.35	13.35
Dug Well	Amvobombe	South	Amvobombe	002	25°11'06.0"	46°5"21.1"	21/9/2005	22	20.32
Dug Well	Amvobombe	South South West	Amvobombe	007	25°11"7.9'	46°4"47'	21/9/2005	13.51	13.36
Dug Well	Amvobombe	South South West	Amvobombe	123	25°11"20.3'	46°4"39.4'	21/9/2005	12.8	13.15
Dug Well	Amvobombe	South-West	Amvobombe	008	25°10"56.9'	46°4"39.9'	21/9/2005	11.8	11.6
Dug Well	Amvobombe	West	Amvobombe	122	25°10"45.6'	46°4"28.8'	21/9/2005	2.4	18.43
Dug Well	Amvobombe	North West	Amvobombe	005	25°10"21.0'	46°4"58.0'	21/9/2005	13.1	13.15
vovo	Amvobombe	North	Amvobombe	282	25°10.268'	46°5.325'	21/9/2005	12	-
Dug Well	Amvobombe	North East	Amvobombe	283	25°10"16.7'	46°5"34.3'	21/9/2005	7.8	7.36
Dug Well	Amvobombe	North East	Amvobombe	284	25°10"26.7'	46°5"33.9'	21/9/2005	8.2	7.92
Dug Well	Antanimora	Center	Antanimora	020	24°48'47.5"	45°39'45.1"	23/9/2005	78	5.63
Dug Well	Antanimora	Center	Antanimora	022	24°48'38.4"	45°40'50.3	23/9/2005	13.5	7.1
Dug Well	Antanimora	Center	Antanimora	140	24°48'52.5"	45°39'5.2"	24/9/2005	15.65	4.33
Dug Well	Antanimora	Center	Antanimora	097	24°42'58.4"	45°39'8.4"	23/9/2005	14.33	3.66
Dug Well	Antanimora	East-South East	Antanimora	148	24°50'25.3"	45°44'26.11"	24/9/2005	20.85	5.82
Dug Well	Antanimora	East-South East	Antanimora	026	24°49'0.5"	45°44'13.2"	24/9/2005	42.39	9.16
Dug Well	Antanimora	East-South East	Ambanisarika	152	24°53'59"	45°52'21"	23/9/2005	42	25.35
Dug Well	Antanimora	South East	Antanimora	016	24°56'31.6"	45°45'48.8"	23/9/2005	29.4	7.23
Dug Well	Antanimora	South East	Antanimora	015	24°59'31"	45°48'00"	23/9/2005	26.5	7.85
Dug Well	Antanimora	South	Antanimora	121	24°53'55.0"	45°40'29.5"	24/9/2005	imp	imp
Dug Well	Antanimora	South	Antanimora	128	24°58'18.9"	45°41'33.7"	24/9/2005	48	23.55
Dug Well	Antanimora	West	Antanimora	088	24°48'58.7"	45°34'49.4"	24/9/2005	12.68	5.6
Dug Well	Antanimora	West	Antanimora	143	24°51'36.2"	45°33'56.2"	24/9/2005	24.3	8.16
Dug Well	Ambondro	-	Ambondro	203	24°12'46.1"	45°48'37.7"	24/9/2005	10.21	5.42
Dug Well	Ambondro	-	Ambondro	301	24°11'15.7"	45°47'3.11"	24/9/2005	imp	imp
Dug Well	Ambondro	-	Ambondro	228	24°13'59.3"	45°47'52.1"	27/9/3005	5.67	2.41
Dug Well	Coastal	-	Maloalomainty	237	25°13"39.2'	46°11"49.2'	22/9/2005	9.25	8.94
Dug Well	Coastal	-	Ambazoa	224	25°20"39.3'	45°54"56.6'	22/9/2005	4.94	4.77
Dug Well	Coastal	-	Antaritarika	216	25°26"39.4'	45°42"36.4'	22/9/2005	8.18	5.34
vovo	Coastal	-	Maloalomainty	608	25°15"56.3'	46°05"33.7'	22/9/2005	-	-
vovo	Coastal	-	Samponera	520	25°11"2.1'	46°20"41.3.'	26/9/2005	9.22	9.02
Dug Well	Ifotaka	-	Ifotaka	266	24°48'4.1"	46°8'10.6"	26/9/2005	9.36	7.23
Dug Well	Tsiombe	-	Tsiombe	JIRAMA T	24°19'8.1"	45°29'2.0	27/9/3005	n.d	n.d
Dug Well	Amboasarry	-	Amboasarry	JIRAMA A	25°1'58.3"	46°22'40.8"	26/9/2005	n.d	n.d

Table 2.4.2-1 (2) Characteristics of Water Quality Analysis sampling points -Other types

Type	Area	Sub-Area	Commune	Sample Name	Lat	Long	Sampling date
Pond	Amvobombe	-	Amvobombe	Pond C	25°4'33.2"	45°59'32.2"	23/9/2005
Pond	Amvobombe	West-North West	Amvobombe	Pond A	25°10.460	46°3.998	21/9/2005
Pond	Antanimora	-	Antanimora	Pond B	24°54'13.4"	45°56'49.9'	23/9/2005
River	Antanimora	Bemamba Riv.	Antanimora	Bemamba Riv.	24°48'55.2"	45°40'fff.7"	23/9/2005
River	Antanimora	Ikonda Riv.	Antanimora	Ikonda Riv.	24°44'28.4"	45°44'5.2"	24/9/2005
River	Tsiombe	Riv. O	Tsiombe	Manavovo Riv.	24°19'0.3"	45°28'42.2"	27/9/3005
River	Amboasarry	Riv. P	Amboasarry	Mandorare Riv.	25°2'5.8"	46°22'14.0"	26/9/2005

Table 2.4.3(1-1) Water Quality Analysis Results - Filed Survey, Shallow and Deep Wells

Type	Area	Sub-Area	Commune	Sample	Well Depth	Results Temp. ℃	Odor	Taste	Color	pH	EC mS/m	DO mg/L	M-Alkality mg/L	CO2 mg/L	Boron mg/L	E. Coli numb/ml	Bacteria numb/ml
						WHO									*0.3*	*0*	
						Madg				*6.5-9*	*300*					*0*	
Shallow well	Amvobombe	West	Amvobombe	122	2.4	25	None	Salty	none	7.4	**1383**	3.6	595	84	0.5	**100**	**100**
Shallow well	Amvobombe	North East	Amvobombe	283	7.8	22	None	Slight Salty	none	7.65	**574**	4.2	450	88	0	**80**	0
Shallow well	Amvobombe	North East	Amvobombe	284	8.2	25	None	Slight Salty	none	7.9	255	6.4	345	31	0.5	**20**	**20**
Shallow well	Amvobombe	South-West	Amvobombe	008	11.8	21	None	None	Light-yellowish	8	216	5.85	450	18	0.5	**100**	**100**
vovo	Amvobombe	North	Amvobombe	282	12	23	None	Salty	Light-yellowish	8.2	228	5.5	350	18	0	0	**40**
Shallow well	Amvobombe	South South West	Amvobombe	123	12.8	26	None	Slight Salty	none	8.1	109.6	3.9	180	9	0.5	**100**	**100**
Shallow well	Amvobombe	East South East	Amvobombe	514	12.9	25	None	None	Light-yellowish	7.6	85	5.9	65	13	0	**100**	**100**
Shallow well	Amvobombe	North West	Amvobombe	005	13.1	22	None	None	none	7.4	**454**	4.3	140	26	0	**10**	**16**
Shallow well	Amvobombe	South	Amvobombe	124	13.35	27	None	None	Light-yellowish	7.9	147	4.3	220	18	0.5	**100**	0
Shallow well	Amvobombe	South South West	Amvobombe	007	13.51	25	None	Slight Salty	none	7.3	246	3.4	260	40	0	0	**40**
Shallow well	Amvobombe	South East	Amvobombe	010	14.15	27	None	None	Light-yellowish	7.8	146	4.5	130	11	0	**40**	**20**
Shallow well	Amvobombe	East South East	Amvobombe	510	14.7	26	None	None	Light-yellowish	8.1	81	6.3	120	9	0	**80**	**80**
Shallow well	Amvobombe	South	Amvobombe	276	16.4	26	None	Slight Salty	none	7.6	**460**	6.5	300	18	0	**100**	**100**
Shallow well	Amvobombe	East South East	Amvobombe	500	18.6	27	None	Slight Salty	none	8.1	95	5	150	13	0	**100**	**100**
Shallow well	Amvobombe	Center	Amvobombe	001	20.4	27	None	None	none	7.1	**692**	4.2	120	26.4	0	0	0
Shallow well	Amvobombe	South	Amvobombe	002	22	24	none	None	none	7.8	241	4.3	405	35	0	**20**	**100**
Shallow well	Amvobombe	South East	Amvobombe	277	25.8	26	None	Slight Salty	none	8	**369**	4.4	210	22	0	**10**	**100**
Shallow well	Amvobombe	South	Amvobombe	134	26.93	25	None	Slight Salty	none	8	**342**	5.3	305	31	0.5	**20**	**40**
Deep Well	Amvobombe	Center	Amvobombe	604	130	26	None	Salty	none	6.9	**1540**	6.5	270	57	0	0	**10**
Shallow well	Antanimora	West	Antanimora	088	12.68	26	None	None	none	8.3	163.2	2.2	625	18	0	**38**	**54**
Shallow well	Antanimora	Center	Antanimora	022	13.5	28	None	None	none	7.7	156.6	6.8	680	9	0	**24**	**90**
Shallow well	Antanimora	Center	Antanimora	097	14.33	26	None	Slight Salty	none	7.9	131.2	3.8	525	22	0	**13**	**16**
Shallow well	Antanimora	Center	Antanimora	140	15.65	28	None	None	none	7.8	69.7	4.2	245	13	0	**5**	**19**
Shallow well	Antanimora	East-South East	Antanimora	148	20.85	26	None	bit-salty	none	7.4	209	5.6	265	35	0	**100**	**20**
Shallow well	Antanimora	West	Antanimora	143	24.3	28	None	Slight Salty	none	8.1	187.5	4.5	475	13	0	**30**	**42**
Shallow well	Antanimora	South East	Antanimora	015	26.5	27	None	Slight Salty	Light-yellowish	7.5	**414**	2.6	395	44	0	**100**	**100**
Shallow well	Antanimora	South East	Antanimora	016	29.4	28	None	None	none	7.3	166.5	3.8	385	66	0	**42**	**26**
Shallow well	Antanimora	East-South East	Ambanisarika	152	42	29	Rotten	Slight Salty	Light-yellowish	7.6	245	2.3	735	44	0.1	**100**	**100**
Shallow well	Antanimora	East-South East	Antanimora	026	42.39	27	None	None	none	7.6	72	5.7	265	26	0	**54**	**37**
Shallow well	Antanimora	South	Antanimora	128	48	27	None	Salty	none	7	**640**	2.2	550	44	0	**40**	**16**
Shallow well	Antanimora	Center	Antanimora	020	78	30	None	None	none	7.7	141.6	2.7	455	22	0	**28**	**45**
Shallow well	Antanimora	South	Antanimora	121	imp	28	None	Bitter	none	7.8	152.3	4.1	460	26	0	**17**	**25**
Shallow well	Ambondro	-	Ambondro	228	5.67	24	None	Rotten	none	7.1	80.8	1.9	90	18	0	**48**	**34**
Shallow well	Ambondro	-	Ambondro	203	10.21	25	None	none	none	7.7	173.5	6.2	130	22	0	**8**	**4**
Shallow well	Ambondro	-	Ambondro	301	imp	24	None	Salty	yellow	7.8	**2430**	3	715	128	0	**13**	**29**
Shallow well	Coastal	-	Ambazoa	224	4.94	25	None	Salty	none	7.7	**666**	5.5	235	35	0	**100**	**100**
Shallow well	Coastal	-	Antaritarika	216	8.18	24	None	Salty	none	7.6	230	2.8	455	35	0	**64**	**100**
vovo	Coastal	-	Samponera	520	9.22	29	None	Salty	none	7.1	**734**	5.5	180	26	0	**100**	**10**
Shallow well	Coastal	-	Maloalomain	237	9.25	25	None	Salty	Light-yellowish	7.3	**1274**	3.6	365	70	0.5	**100**	**100**
vovo	Coastal	-	Maloalomain	608	-	24	None	Salty	Light-yellowish	7.5	**1487**	7.2	160	31	0	**100**	**100**
Shallow well	Ifotaka	-	Ifotaka	266	9.36	29	None	None	none	8.1	35.4	5.3	155	13	0	**13**	**35**
Shallow well	Tsiombe	-	Tsiombe	JIRAMA T	n.d	27	None	Salty	none	7.2	**430**	0.8	390	35	0	**7**	**9**
Shallow well	Amboasarry	-	Amboasarry	JIRAMA A	n.d	26	None	bit-salty	none	7.6	270	3.2	395	31	0	**13**	**17**

Note: The data in **Bold** are data which is over the standard.

Table 2.4.3 (1-2) Water Quality Analysis Results - Filed Survey, Others

Type	Area	Sub-Area	Commune	Sample	Results												
						Temp. ℃	Odor	Taste	Color	pH	EC mS/m	DO mg/L	M-Alkality mg/L	CO2 mg/L	Boron mg/L	E. Coli numb/ml	Bacteria numb/mL
					WHO Std.										*0.3*	*0*	
					Madag. Std					*6.5-9*	*300*					*0*	
Pond	Amvobombe	-	Amvobombe	Pond C		26	None	Clayish	Light-yellowish	8.3	38	4.8	165	2	0	**44**	**60**
Pond	Amvobombe	West-North West	Amvobombe	Pond A		28	None	Clayish	brown	7.8	131.8	5	195	6	0	**100**	**100**
Pond	Antanimora	-	Antanimora	Pond B		32	None	None	Light-yellowish	7.3	71.3	3.6	265	26	0	**100**	**100**
River	Antanimora	Bemamba Riv.	Antanimora	hamba Riv.		25	None	None	none	7.9	87.3	3.2	355	9	0	**46**	**100**
River	Antanimora	Ikonda Riv.	Antanimora	konda Riv.		22	None	none	none	8.2	76.2	7.6	315	4	0	**100**	44
River	Tsiombe	Riv. O	Tsiombe	avovo Riv.		27	None	none	none	7.9	119	2.4	205	5	0	**60**	**76**
River	Amboasarry	Riv. P	Amboasarry	dorare Riv.		28	None	None	none	8.5	75.8	6.1	160	1	0	**15**	**10**

Table 2.4.3 (2-1) Water Quality Analysis results - Laboratory Results (Metallic Ion) : Shallow and Deep Wells

Type	Area	Sub-Area	Commune	Sample	Well depth	Potassium	Sodium	Calcium	Magnesium	Iron	Manganese	Arsenic
						K	Na	Ca	Mg	Fe	Mn	As
						mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
						WHO Std.	*200*			*0.3*	*0.5*	*0.01*
						Madag. Std		*200*	*50*	*0.5*	*0.05*	*0.05*
Shallow well	Amvobombe	West	Amvobombe	122	2.4	250.20	**2413.86**	**473.60**	**263.90**	0.04	*0.18*	0.00
Shallow well	Amvobombe	North East	Amvobombe	283	7.8	65.90	**480.73**	188.00	**171.56**	0.01	*0.23*	0.00
Shallow well	Amvobombe	North East	Amvobombe	284	8.2	30.00	**275.11**	54.40	**58.98**	0.00	*0.09*	0.00
Shallow well	Amvobombe	South-West	Amvobombe	008	11.8	39.00	**262.95**	19.44	12.00	0.15	*0.14*	0.00
vovo	Amvobombe	North	Amvobombe	282	12	24.10	**330.39**	32.00	47.63	0.15	*0.24*	0.00
Shallow well	Amvobombe	South South West	Amvobombe	123	12.8	7.18	**202.76**	14.40	22.84	0.15	0.00	0.00
Shallow well	Amvobombe	East South East	Amvobombe	514	12.9	15.65	96.60	32.00	12.15	0.25	*0.18*	0.00
Shallow well	Amvobombe	North West	Amvobombe	005	13.1	55.30	113.67	132.80	**91.85**	0.01	*0.14*	0.00
Shallow well	Amvobombe	South	Amvobombe	124	13.35	13.63	**241.67**	4.80	19.44	*0.30*	0.02	0.00
Shallow well	Amvobombe	South South West	Amvobombe	007	13.51	25.75	**376.41**	10.40	10.21	0.06	0.00	0.00
Shallow well	Amvobombe	South East	Amvobombe	010	14.15	33.15	158.86	17.98	12.80	0.15	*0.15*	0.00
Shallow well	Amvobombe	East South East	Amvobombe	510	14.7	6.50	110.40	20.00	41.31	0.15	*0.12*	0.00
Shallow well	Amvobombe	South	Amvobombe	276	16.4	36.05	**687.35**	64.80	47.14	0.00	0.00	0.00
Shallow well	Amvobombe	East South East	Amvobombe	500	18.6	9.35	140.83	21.60	16.52	0.00	*0.08*	0.00
Shallow well	Amvobombe	Center	Amvobombe	001	20.40	247.40	**570.40**	**330.40**	**216.76**	0.00	0.00	0.00
Shallow well	Amvobombe	South	Amvobombe	002	22	19.90	157.55	88.80	31.10	0.00	*0.06*	0.00
Shallow well	Amvobombe	South East	Amvobombe	277	25.8	38.00	**241.60**	146.40	15.07	0.00	0.00	0.00
Shallow well	Amvobombe	South	Amvobombe	134	26.93	32.75	**464.26**	113.60	**54.92**	0.00	*0.12*	0.00
Deep Well	Amvobombe	Center	Amvobombe	604	130	141.00	**3298.20**	**1064.00**	**556.47**	0.01	*0.12*	0.00
Shallow well	Antanimora	West	Antanimora	088	12.68	1.79	**300.53**	13.60	26.73	0.00	0.01	0.00
Shallow well	Antanimora	Center	Antanimora	022	13.5	1.14	139.67	69.60	**80.68**	0.00	0.00	0.00
Shallow well	Antanimora	Center	Antanimora	097	14.33	3.36	**160.35**	19.20	32.56	0.00	*0.09*	0.00
Shallow well	Antanimora	Center	Antanimora	140	15.65	2.32	99.92	18.40	25.27	0.00	*0.10*	0.00
Shallow well	Antanimora	East-South East	Antanimora	148	20.85	7.65	**243.30**	57.60	47.14	0.00	*0.13*	0.00
Shallow well	Antanimora	West	Antanimora	143	24.3	0.52	**419.66**	17.60	17.01	0.00	0.01	0.00
Shallow well	Antanimora	South East	Antanimora	015	26.5	16.20	**584.06**	160.00	**218.70**	**0.50**	**0.71**	0.00
Shallow well	Antanimora	South East	Antanimora	016	29.4	16.35	141.39	99.20	**55.40**	0.00	0.02	0.00
Shallow well	Antanimora	East-South East	Ambanisarika	152	42	17.95	**950.81**	57.60	**83.13**	0.03	**0.71**	0.00
Shallow well	Antanimora	East-South East	Antanimora	026	42.39	19.90	46.00	19.20	17.01	*0.40*	0.00	0.00
Shallow well	Antanimora	South	Antanimora	128	48	33.30	**802.99**	196.00	**318.33**	0.00	*0.10*	0.00
Shallow well	Antanimora	Center	Antanimora	020	78	3.60	**208.76**	56.00	33.53	0.00	0.01	0.00
Shallow well	Antanimora	South	Antanimora	121	imp	2.85	**238.46**	39.20	23.81	0.00	*0.11*	0.00
Shallow well	Ambondro	-	Ambondro	203	10.21	21.10	**202.40**	13.60	20.41	0.00	0.00	0.00
Shallow well	Ambondro	-	Ambondro	301	imp	2665.00	**2921.00**	**800.00**	**1015.74**	0.00	*0.16*	0.00
Shallow well	Ambondro	-	Ambondro	228	5.67	11.05	109.70	28.00	34.99	0.06	*0.08*	0.00
Shallow well	Coastal	-	Maloalomain	237	9.25	264.00	**1946.00**	**372.00**	**291.60**	0.00	*0.08*	0.00
vovo	Coastal	-	Maloalomain	608	-	58.80	**3206.20**	**800.00**	**551.61**	0.00	*0.09*	0.00
Shallow well	Coastal	-	Ambazoa	224	4.94	87.45	**912.30**	**276.80**	**167.18**	0.00	0.01	0.00
vovo	Coastal	-	Samponera	520	9.22	15.35	**1403.00**	**384.00**	**191.48**	0.00	*0.11*	0.00
Shallow well	Coastal	-	Antaritarika	216	8.18	9.70	**395.27**	60.80	**57.83**	0.00	0.00	0.00
Shallow well	Ifotaka	-	Ifotaka	266	9.36	1.36	25.30	46.00	28.55	0.00	*0.12*	0.00
Shallow well	Tsiombe	-	Tsiombe	JIRAMA T	n.d	31.20	**588.80**	**85.60**	**122.96**	0.00	*0.10*	0.00
Shallow well	Amboasarry	-	Amboasarry	JIRAMA A	n.d	8.90	**386.40**	72.00	**134.14**	0.00	*0.46*	0.00

Table 2.4.3 (2-2) Water Quality Analysis results - Laboratory Results (Metallic Ion) : Others

Type	Area	Sub-Area	Commune	Sample	Results	Potassium	Sodium	Calcium	Magnesium	Iron	Manganese	Arsenic
						K	Na	Ca	Mg	Fe	Mn	As
						mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
					WHO Std.		*200*			*0.3*	*0.5*	*0.01*
					Madag. Std			*200*	*50*	*0.5*	*0.05*	*0.05*
Pond	Amvobombe	-	Amvobombe	Pond C		52.30	57.50	76.00	43.74	**2.50**	**1.34**	0.00
Pond	Amvobombe	West-North West	Amvobombe	Pond A		281.60	138.00	43.20	**129.28**	**12.50**	**1.31**	0.00
Pond	Antanimora	-	Antanimora	Pond B		11.23	13.02	44.00	12.15	0.06	*0.16*	0.00
River	Antanimora	Bemamba Riv.	Antanimora	amba Riv.		4.17	36.80	33.60	24.30	0.00	*0.16*	0.00
River	Antanimora	Ikonda Riv.	Antanimora	konda Riv.		4.30	42.55	58.00	**56.50**	0.00	*0.14*	0.00
River	Tsiombe	Riv. O	Tsiombe	avovo Riv.		10.10	184.00	49.60	**55.40**	0.04	*0.31*	0.00
River	Amboasarry	Riv. P	Amboasarry	dorare Riv.		3.05	87.40	48.00	19.44	0.02	*0.13*	0.00

Table 2.4.3 (3-1) Water Quality Analysis results - Laboratory Results (Others) : Shallow and Deep Wells

Type	Area	Sub-Area	Commune	Sample	Chloride	Sulfate	Bicarbonate	Nitrite	Nitrate	Ammonium	Fluoride	Turbidity	T-Hardness
					Cl	SO4	HCO3	NO2	NO3	NH4	F		
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	F
					250	*250*		*3*	*50*	*1.5*	*1.5*	*5*	
					250	*250*		*0.1*	*50*	*0.5*	*1.5*		*50*
Shallow well	Amvobombe	West	Amvobombe	122	**3862.40**	**1856.30**	536.80	0.01	0.01	0.16	1.41	2.28	**227.00**
Shallow well	Amvobombe	North East	Amvobombe	283	**1086.30**	**360.12**	444.08	**9.37**	71.54	0.00	0.28	7.33	**117.60**
Shallow well	Amvobombe	North East	Amvobombe	284	**497.00**	70.70	341.60	*0.18*	1.44	0.04	0.01	**10.40**	37.87
Shallow well	Amvobombe	South-West	Amvobombe	008	237.85	83.70	407.48	**3.45**	9.08	0.06	0.00	**99.40**	11.00
vovo	Amvobombe	North	Amvobombe	282	**475.70**	70.71	356.24	*2.63*	15.50	0.02	0.30	**36.10**	27.60
Shallow well	Amvobombe	South South West	Amvobombe	123	234.30	91.65	214.72	0.04	0.48	0.00	0.17	**10.10**	13.00
Shallow well	Amvobombe	East South East	Amvobombe	514	149.10	40.26	63.44	*0.23*	2.28	0.00	0.00	2.94	13.00
Shallow well	Amvobombe	North West	Amvobombe	005	**351.45**	**269.30**	151.28	**5.09**	**85.94**	0.08	0.36	**9.29**	71.00
Shallow well	Amvobombe	South	Amvobombe	124	**276.90**	168.05	122.00	*0.13*	0.81	0.06	0.00	**81.40**	9.20
Shallow well	Amvobombe	South South West	Amvobombe	007	**301.75**	**254.94**	292.80	**6.41**	14.18	0.00	0.11	**6.59**	6.80
Shallow well	Amvobombe	South East	Amvobombe	010	**284.00**	10.45	136.64	*0.14*	1.28	0.00	0.00	**50.80**	10.60
Shallow well	Amvobombe	East South East	Amvobombe	510	170.40	35.10	119.56	0.02	1.11	0.00	0.00	2.48	22.20
Shallow well	Amvobombe	South	Amvobombe	276	**1050.80**	185.36	283.04	**5.26**	38.09	0.02	0.00	1.94	35.06
Shallow well	Amvobombe	East South East	Amvobombe	500	220.10	8.82	163.48	*0.13*	2.41	0.00	0.20	1.50	12.20
Shallow well	Amvobombe	Center	Amvobombe	001	**880.40**	**371.46**	129.32	*0.43*	3.73	0.14	0.62	1.12	**171.80**
Shallow well	Amvobombe	South	Amvobombe	002	**259.15**	48.81	395.28	0.03	1.66	0.04	0.14	1.06	35.00
Shallow well	Amvobombe	South East	Amvobombe	277	**454.40**	155.60	190.32	*2.79*	**100.34**	0.00	0.00	1.58	42.80
Shallow well	Amvobombe	South	Amvobombe	134	**908.80**	55.58	324.52	0.02	0.73	0.02	0.76	**8.26**	11.60
Deep Well	Amvobombe	Center	Amvobombe	604	**5090.70**	**630.42**	63.44	0.04	1.77	0.42	0.37	**7.92**	**495.00**
Shallow well	Antanimora	West	Antanimora	088	78.10	90.36	722.24	**6.25**	3.98	0.00	0.57	1.05	14.40
Shallow well	Antanimora	Center	Antanimora	022	149.10	27.94	695.40	0.00	0.01	0.00	0.74	1.70	**50.60**
Shallow well	Antanimora	Center	Antanimora	097	113.60	152.60	549.00	**3.78**	3.54	0.02	1.08	0.85	18.20
Shallow well	Antanimora	Center	Antanimora	140	49.70	31.65	329.40	0.05	0.30	0.00	0.44	1.25	15.00
Shallow well	Antanimora	East-South East	Antanimora	148	**319.64**	181.82	319.64	0.09	0.66	0.04	0.00	1.23	33.80
Shallow well	Antanimora	West	Antanimora	143	**369.20**	146.52	480.68	*0.28*	0.06	0.00	0.00	2.48	11.40
Shallow well	Antanimora	South East	Antanimora	015	**1178.60**	30.81	446.52	0.00	0.19	0.08	0.36	**12.40**	**76.00**
Shallow well	Antanimora	South East	Antanimora	016	227.20	128.94	439.20	0.00	0.19	0.04	0.50	1.10	0.50
Shallow well	Antanimora	East-South East	Ambanisarik	152	**994.00**	**546.02**	734.44	0.09	0.12	0.04	0.95	**48.30**	48.20
Shallow well	Antanimora	East-South East	Antanimora	026	71.00	60.49	324.52	0.00	0.07	0.00	0.47	4.27	11.80
Shallow well	Antanimora	South	Antanimora	128	**276.90**	**1590.40**	629.52	0.00	0.19	0.16	0.76	**8.26**	**118.60**
Shallow well	Antanimora	Center	Antanimora	020	142.00	62.29	546.56	0.00	0.09	0.00	1.17	0.92	27.80
Shallow well	Antanimora	South	Antanimora	121	163.30	151.06	573.40	0.04	0.49	0.02	0.54	0.74	19.60
Shallow well	Ambondro	-	Ambondro	203	**312.40**	145.35	146.40	0.02	**194.00**	0.00	0.60	**9.61**	11.80
Shallow well	Ambondro	-	Ambondro	301	**4508.50**	**1671.70**	851.56	**19.74**	**614.88**	0.34	0.25	4.96	**618.00**
Shallow well	Ambondro	-	Ambondro	228	191.70	116.12	102.48	0.04	0.04	0.02	0.34	1.80	21.40
Shallow well	Coastal	-	Maloalomain	237	**3727.50**	**1081.40**	368.44	*2.96*	5.32	0.24	1.19	**29.60**	**213.00**
vovo	Coastal	-	Maloalomain	608	**4948.70**	**581.16**	104.92	*0.72*	1.71	0.32	1.17	**10.80**	**427.00**
Shallow well	Coastal	-	Ambazoa	224	**2101.60**	**321.80**	224.48	*0.99*	1.87	0.14	0.78	1.80	**138.00**
vovo	Coastal	-	Samponera	520	**2165.50**	157.10	226.92	*0.22*	1.54	0.22	0.08	2.30	**174.80**
Shallow well	Coastal	-	Antaritarika	216	**426.00**	**285.12**	466.04	*2.17*	1.06	0.00	0.49	2.56	39.00
Shallow well	Ifotaka	-	Ifotaka	266	39.05	23.93	176.90	0.06	0.31	0.00	0.00	1.03	23.25
Shallow well	Tsiombe	-	Tsiombe	JIRAMA T	**908.80**	**303.34**	366.00	*2.72*	7.51	0.08	0.20	1.47	**72.00**
Shallow well	Amboasarry	-	Amboasarry	JIRAMA A	**596.40**	186.73	407.48	*0.12*	0.09	0.04	0.43	1.66	**73.20**

Table 2.4.3 (3-2) Water Quality Analysis results - Laboratory Results (Others) : others

Type	Area	Sub-Area	Commune	Sample	Chloride	Sulfate	Bicarbonate	Nitrite	Nitrate	Ammonium	Fluoride	Turbidity	T-Hardness
					Cl	SO4	HCO3	NO2	NO3	NH4	F		
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	F
					250	*250*		*3*	*50*	*1.5*	*1.5*	*5*	
					250	*250*		*0.1*	*50*	*0.5*	*1.5*		
Pond	Amvobombe	-	Amvobombe	Pond C	88.75	13.00	268.40	0.00	0.00	0.00	0.00	**371.00**	37.00
Pond	Amvobombe	West-North West	Amvobombe	Pond A	213.00	135.02	214.72	0.00	0.00	0.04	0.00	**2970.00**	64.00
Pond	Antanimora	-	Antanimora	Pond B	42.60	3.39	170.80	0.00	0.00	0.02	0.00	**38.40**	16.00
River	Antanimora	Bemamba Riv.	Antanimora	amba Riv.	56.80	38.41	405.04	*0.15*	1.47	0.00	0.20	3.94	18.40
River	Antanimora	Ikonda Riv.	Antanimora	konda Riv.	37.75	65.67	353.80	0.06	0.26	0.04	0.43	3.17	37.75
River	Tsiombe	Riv. O	Tsiombe	avovo Riv.	28.00	9.98	178.12	0.06	0.16	0.04	0.00	**32.60**	35.20
River	Amboasarry	Riv. P	Amboasarry	dorare Riv.	134.90	7.87	173.24	0.00	0.00	0.00	0.40	5.00	20.00

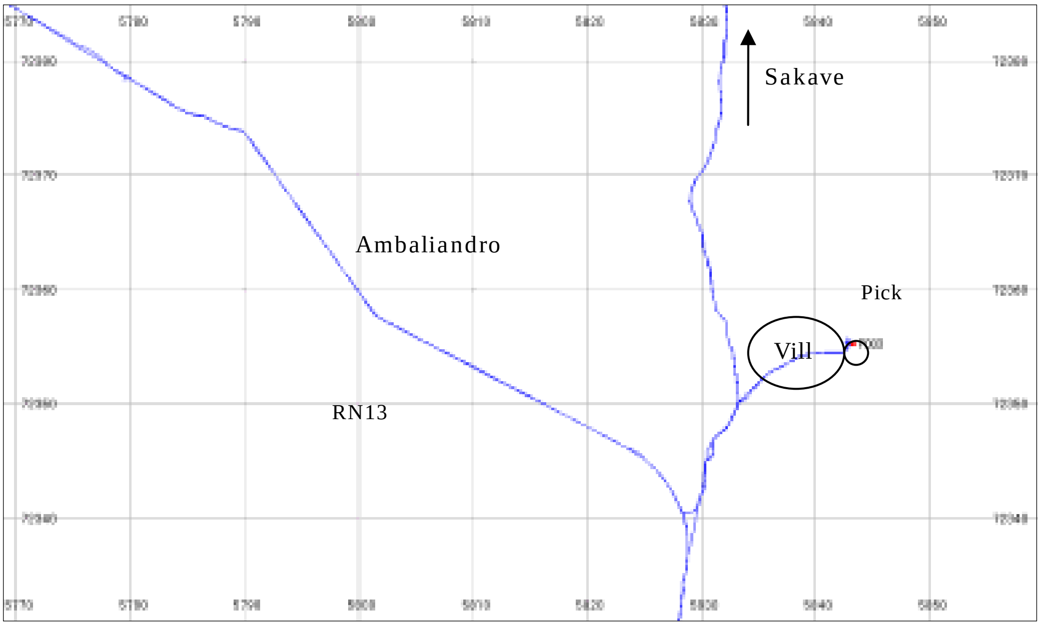
DP2.5 Drilling Site

The following are the details of each test drilling site, which is consisted of:
1) Location map
2) Hydrogeological condition
3) Information to identify point
4) Important check points during drilling

(1) P003 Ambalantsaraky

1) Location map

The nearest village is located 1km south of the Sakave village, and is about 2km east from RN13 near Ambaliandro. GPS is a necessity to find the exact position of the site, but the villagers shall arrange for the access road prior to the commencement of digging.



Notes: one section is 1km

2) Hydrogeological condition

The site is located at the plain of the north western side of the Ambovombe basin. This area turns to a flooded area during rain season. Unconsolidated sand can be expected to cover the surface in the view of topographical and hydrogeological points.

- Plain
- Shrub
- Unconsolidated sand

3) Information to identify the points

There is a shallow dug well at Ambaliandro. Water has high salinity and is used to fetch livestock during dry season.

4) Important observation during drilling

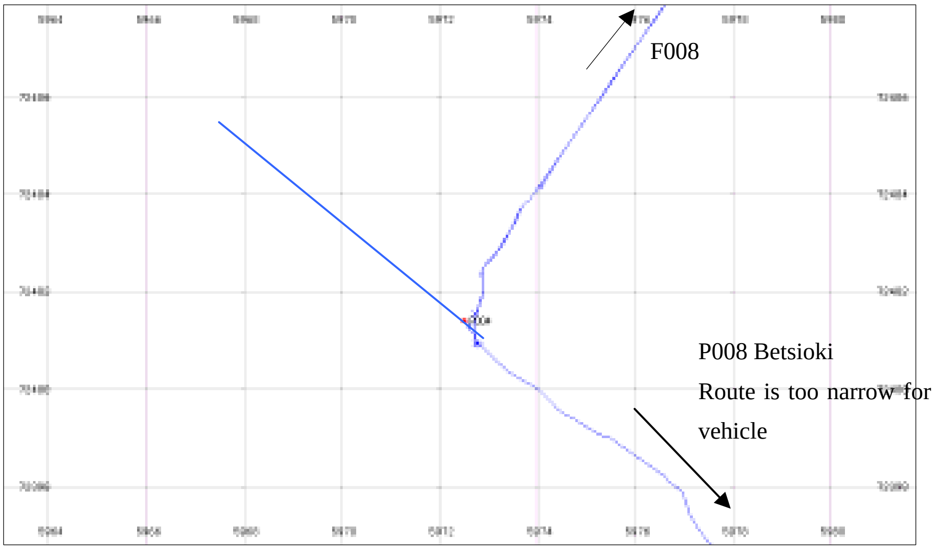
Objective of the shallow dug well construction is to obtain data, as there is not enough data available to establish several gradients. Furthermore, the following information shall help to understand the hydrogeology of the basin.

- Fundamental hydrogeological information, especially groundwater recharge mechanism
- Groundwater quality profiling by depth
- Salinity content in the basin
- Comparison of geology between P004 and P008 in the Ambovombe area

(2) P004 Ampanihy

1) Location map

Site location is about 7km south to Sakave along the bush road. GPS is a necessity to find the exact position of the site. It is located at the center of the old village, at the intersection of the road to F008, P008 in Betsioki.



Notes: one section is 200m

2) Hydrogeological condition

The site is located at the plain of the northern-centre of the Ambovombe basin. Access to this area may become worse during rain season, but it seems to be not too swampy for the vehicles to reach the site. Unconsolidated sand can be expected to cover the surface in the view of topographical and hydrogeological points. Unconfined water is expected in this area.

- Plain
- Shrub
- Unconsolidated sand
- 5-10km away from the basement rock area

3) Information to identify the points

- Situated at the center of old village
- Villagers does not want outside people gathering to get water

4) Important observation during drilling

There is no borehole data around this area. The nearest water point is Sakave which is 5-8km away to north-west. This site is important to decide the direction of groundwater gradient whether it is directed to east or to south.

Furthermore, the following information shall help to understand the hydrogeology of the basin.

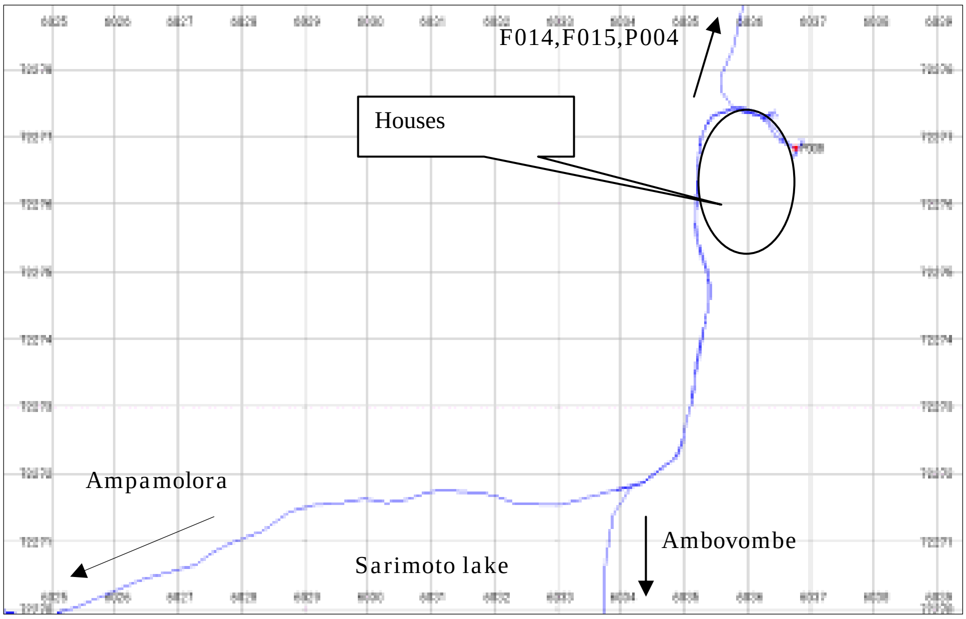
- Fundamental hydrogeological information, especially groundwater recharge mechanism
- Groundwater quality profiling by depth

- Salinity content in the basin
- Comparison of geology between P003 and P008, Ambovombe area and Sakave area

(3) P008 Betioky

1) Location map

Site location is the north east from the Lake Sarimonto, located near branch road from Ampamolora, Ambovombe, and Sakave. It is easy to reach there because the village situated is the major Fokontany having school, etc. The point is located beside a house opposite to the school. The locations is on the way to P004, F008 and F014.



Notes: one section is 100m

2) Hydrogeological condition

The site is located at the rim of the flooded plain of Lake Sarimonto, but this area is slightly higher than plain Unconsolidated sand or clay-silt is expected to cover the surface in the view of topographical and hydrogeological points.

- Plain
- shrub
- Near to the Lake Sarimoto
- Thick clay sedimentation expected

3) Information to identify the points

- next to school in the village
- Plenty of swamp come out near village during rainy season

4) Important observation during drilling

There is no shallow dug well around except Ampamolora. This point is important to establish several property's gradients. Furthermore, the following information shall help to understand the hydrogeology of the basin.

- Fundamental hydrogeological information, especially groundwater recharge mechanism
- Groundwater quality profiling by depth
- Salinity content in the basin
- Comparison of geology with P003, P004, Ambovombe

(4) P009

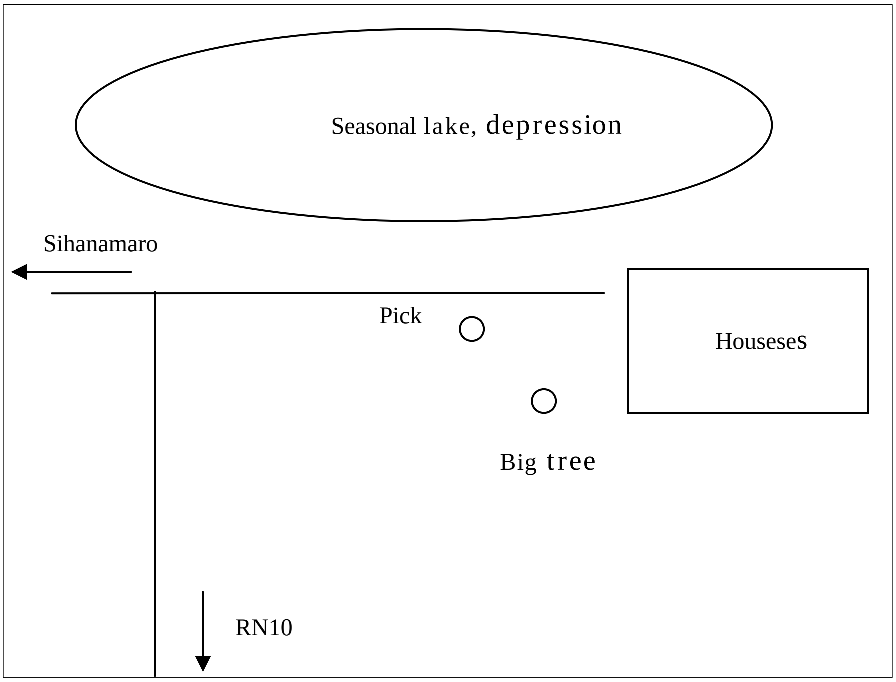
The original site was located in the center of a village along RN13, which was recommended by the commune Mayor. However, based on the results of the monitoring wells, the site is much influenced by salinity. Therefore, a new site was selected inside the village, 2km south east from the original point.

(5) P010 Analajsoka

1) Location map

There is two different access roads. One is access from Sihanamaro. The other is access directly from RN10 passing a route like dried up stream. If it rains, access from Sihanamaro should be much easier. Site is in the small village which is facing huge depression at the north.

- Huge seasonal swamp at the north of village
- Near to the a tree
- At west of houses



Notes: No scale

2) Hydrogeological condition of village

The site is located at the plain where plenty of swamp come out during rain season. Unconsolidated sand or silty sand is expected to cover the surface in the view of topography and covering surface.

Scarce vegetation indicates the existence of sand at the surface to certain depth which can hardly keep moisture for plants to exist.

- Plain
- Scarce vegetation
- Scarce agriculture activity
- Seasonal swamp is situated at just beside to the north.
- Unconsolidated sand is expected

3) Information to identify the points

- Next to depression
- Big tree
- A lot of swamp exists

4) Important observation during drilling

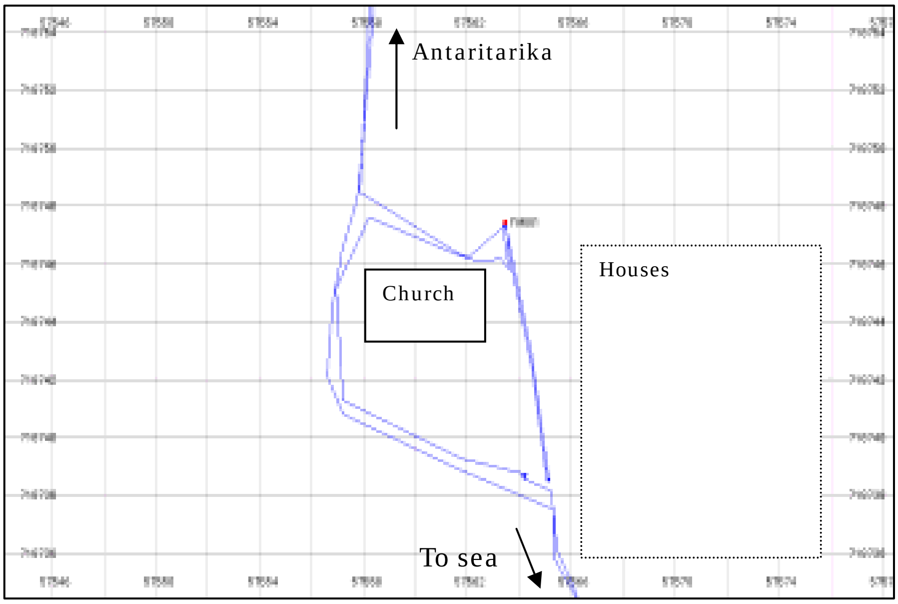
There is a lot of shallow dug well in the surroundings, but have rich salinity. Main objective of drilling the test borehole is to find out if it is worth to exploit for pilot project. It requires information to justify as water source.

- Aquifer characteristics
- Fundamental hydrogeological information for groundwater movement
- Salinity content in the basin
- Comparison with other shallow wells

(6) FM001 Marofo

1) Location Map

The drilling point is situated at the entrance of the village. Village is on the way to the coast from Antaritarika. Road to the sea is not only one, so that it is needed to ask village people passing by on the road. Village has a big church and relatively large number of habitants.



Notes: one section is 20m

2) Hydrogeological condition

The site is located at the slope of the coastal dune. Assuming the dune is consisted with permeable sand, fresh water sits on the saline water around sea level. According to the specification of the manual pump manufacturer, the capacity of the manual pump is around 100m. Therefore, the altitude of the drilling point should be set lower than 85m to keep space for pump installation.

- Slope of dune
- High permeable sand is expected
- Static water level is expected to be equal to sea level.
- Estimated altitude is 84m (GPS altitude is 91.2m while GPS SWL is 7.2m)

3) Information to identify the points

- Village people draw water at the Mananvvovo river or at the dug well situated sea shore
- Church exists
- Village people mostly live on fishing

4) Important observation during drilling

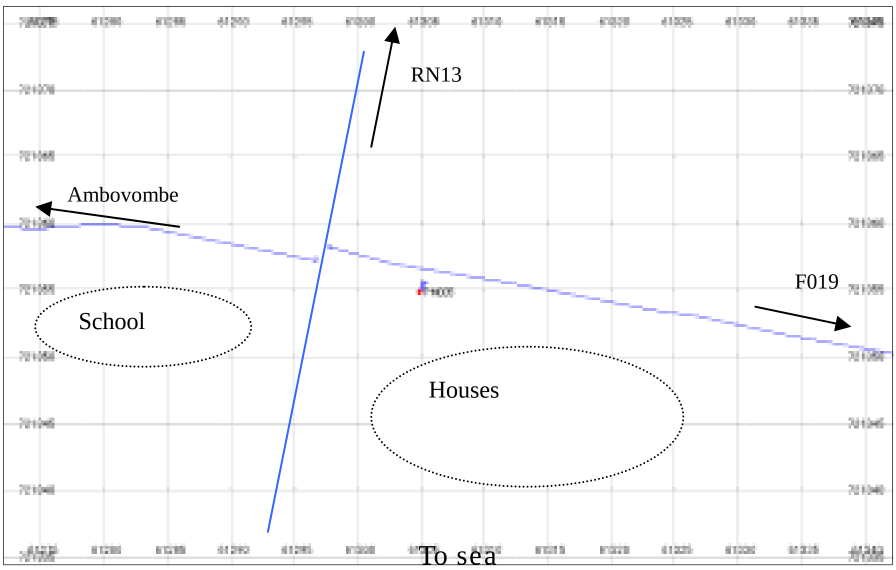
The assumption of the hydrogeological characteristics of this area is high permeable unconsolidated sand penetrating down to the sea level. and thus the aquifer exist at the sea level. If this assumption is not correct, then the recharge mechanism is not done by rainfall directly and is done by lateral movement and percolation at limited area. Assumption must be verified to justify potential of groundwater.

- Drilling depth is 100m
- Permeability of formation
- Estimated depth of aquifer is 84m (GPS SWL 7.2m GPS 91.2m)
- Deeper aquifer must be contaminated sea water
- 4 m-space for pump installation, install only one screen to avoid saline aquifer

(7) PM005 Lavaadrandra

1) Location Map

The village is situated on the slope of the coastal dune, which is the most inner (northern) among the three sand dunes. The village can be accessed Ambovombe passing southeast along the major route. The village stretches for further distance along the route.



Notes: one section is 50m

2) Hydrogeological condition

Village situated on the slope of the coastal dune, which is the most inner among the three dunes. Rainfall should recharge groundwater to the Ambovombe area naturally in the view of topography.

Surface layer is assumed to be unconsolidated sand.

- Upper part of slope of the coastal dune
- Unconsolidated sand is expected
- Groundwater recharge area for groundwater of Ambovombe

3) Information to identify the points

- Objectf Sud has a project with a rain harvest system
- Village coverage is large
- Major Fokontany

4) Important observation during drilling

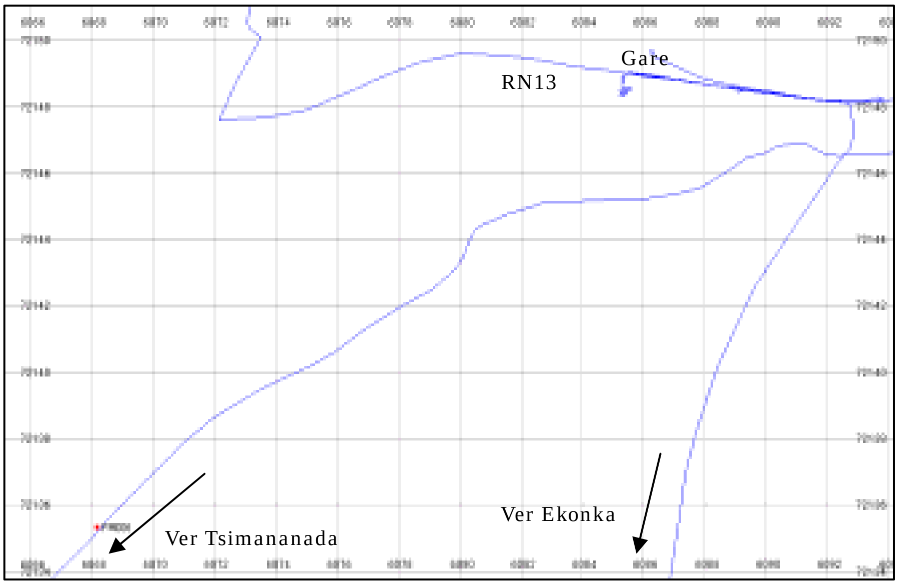
This area is expected as recharge point for the groundwater of Ambovombe. Otherwise rainfall just percolate to impermeable layer which is much deeper than ground water level of Ambovombe.

- Aquifer depth comparing one of Ambovombe
- Formation permeability
- Salinity profiling
- 80m depth is equal to the depth of source of shallow well at Ambovombe.

(8) PM006 Tsimihevo

1) Location map

Drilling point is situated on the slope of the coastal dune, which is the most inner among the three dunes. The drilling point is not near houses, but on the way to Tsimananada from Ambovombe.



Notes: one section is 200m

2) Hydrogeological condition of village

Village situated on the slope of the coastal dune, which is the most inner among the three dunes. Rainfall should recharge groundwater to the Ambovombe area naturally in the view of topography.

Surface layer is assumed to be unconsolidated sand.

- Lower part of slope of the coastal dune
- Unconsolidated sand is expected
- Groundwater recharge area for groundwater of Ambovombe
- VES and 2D resistivity survey indicates higher resistivity of formation at the shallower than 50m.

3) Information to identify the points

- No houses are around , but in the farmland
- Much closer to Ambovombe than Tsimananada
- Near an avenue lined with *poplar trees*
- The western side of road is owned by residents of Tsimananada, but the eastern side is owned by residents of Ambovombe.

4) Important observation during drilling

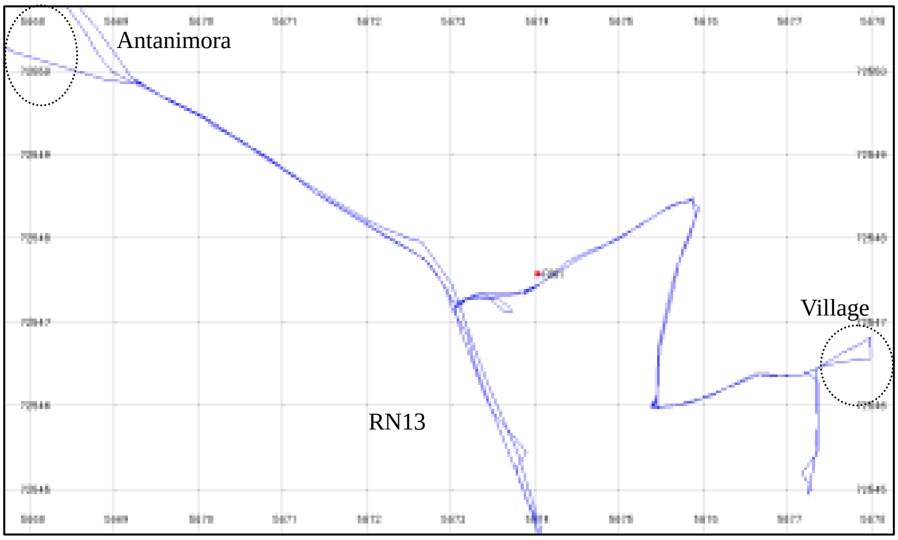
This area is expected as recharge point for groundwater Ambovombe. Otherwise rainfall just percolate to impermeable formation which is much deeper than ground water level of Ambovombe.

- Aquifer depth comparing one of Ambovombe
- Formation permeability
- Salinity profiling
- 50m depth is equal to the source of shallow well at Ambovombe. Only one 6m screen shall be installed at the bottom.

<u>(9) F001 Fiarenantsoa-Amposy</u>

1) Location map

The drilling point is along the RN13, but 100m away to the east in the bush. The RN13 go over a hill 300m away from town, then change direction. The site is owned by a villagers living 400m away.



Notes: one section is 100m

2) Hydrogeological condition

Geology is basically consisted of gneiss with quartz silt, sandstone and limestone. Outcrop is fairly fractured. This point is located on the extension of a major lineament found on the aero photo although it is difficult to recognize at the field. This lineament coincides with the RN13, and crosses over hills stretching from west to east.

The flowing direction of the Bemamba river is influenced by the direction of lineaments based on the observation from the aero photo. The directions of these lineaments are 150-330degrees to the east and 120-300degress to the east. This area is on the lineament extension of 120-300degrees.

- Along extension of major lineament
- The RN13 traverse a hills west to east
- This area is at the extension of lineament which define direction the Bemamba river
- Hardrock
- Outcrop is fairly fractured.

3) Information to identify the points

The use of the point was accepted with appearance owner and authority of Antanimora.

- Land is privately owned by M. BIEN ETRE of village Fiarenantsoa-Amposy
- M. Tsiandare Gabliel, 2em adjoint du Maire was around
- 100m away from RN13

4) Important observation during drilling

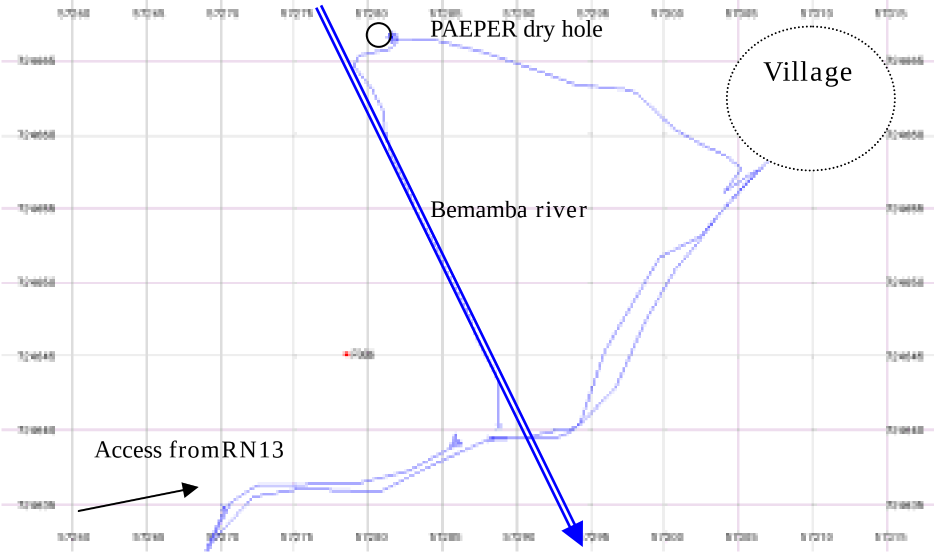
This point is a candidate water source for GFS system to supply water to Ambovombe. The stability and quality water must be confirmed.

- Yield of each aquifers
- EC depth profiling
- Iron content
- Quality of aquifer

(10) F006 Bemamba

1) Location map

The drilling point is near Bemamba-Antsatra village, beside the Bemamba River. The proposed drilling point is on the opposite side of the village and PAEPAR dry hole. An access toad for trucks to the village was prepared during PAEPAR project which still remains. There is a sisal plant at the turning point as a sign of the entrance from the RN13.



Notes: one section is 50m

2) Hydrogeological condition of village

The point situates just near the flood line of Bemamba River. Geology expected is assumed to be sand layer in great depth in the view of topography.

- near Bemamba river.
- Thick sand is expected.
- Plain
- Forest

3) Information to identify the points

- No water source in the village
- One drywell by PAEPAR
- There are boreholes equipped with manual pump(Belona, Vergnet old, India MKII) in the surrounding villages
- A lot of village has a name of Bemamba around this area.
- The site is selected so for the reason that in case of this point source is used as a water source, there shall be no need for the transmission pipeline to cross the river since it will be on the same side of the RN13, the main route where the main pipeline to Ambovombe area shall be laid.

4) Important observation during drilling

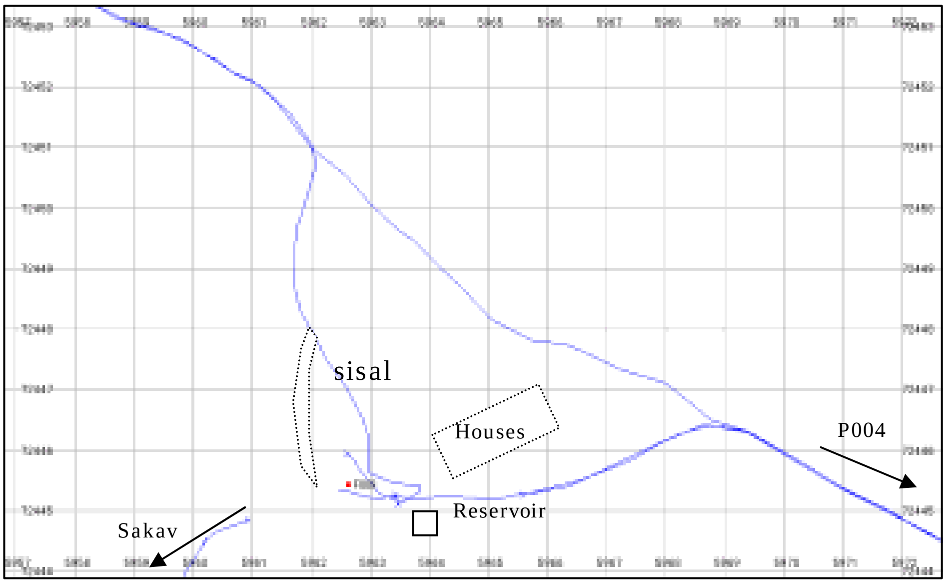
This point is candidate water source for GFS system to supply water to Ambovombe. The stability and quality water must be confirmed. It also important to collect information of depth of basement and aquifer structure.

- Justification as a water source for Ambovombe
- Yield of each aquifers
- EC depth profiling
- Iron content
- Quality of aquifer
- Basement depth
- Fundamental hydrogelogiccal information

(11) F009 Lefonjavy

1) Location map

Site location is about 5km east of Sakave along a bush road. GPS is a necessity to find the exact position of the site The point is located to in the village.



Notes: one section is 100m

2) Hydrogeological condition

The site is located at the plain of the northern-centre of the Ambovombe basin. Access to this area may become worse during rain season, but it seems to be not too swampy for the vehicles to reach the site. Unconsolidated sand can be expected to cover the surface in the view of topographical and hydrogeological points. Unconfined water is expected in this area.

- Plain
- Shrub
- Unconsolidated sand
- Scarce agriculture activity
- 5-10km to hard rock area

3) Information to identify the points

- Point is beside of houses
- Sisal grow naturally near drilling point
- Current water source is seasonal pond several km away from village
- Reservoir basin exist in the village

4) Important observation during drilling

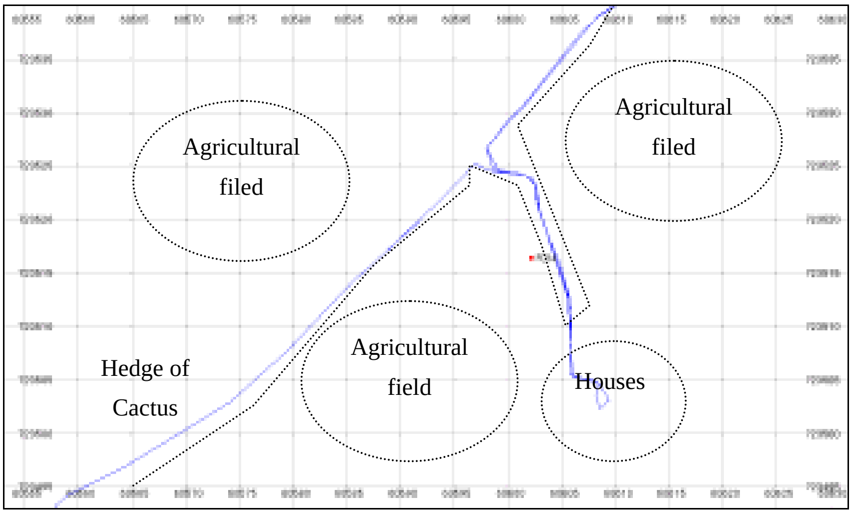
This area is expected transient zone between hard rock area to sediment area. It is important to collect information of depth of basement and aquifer structure because of identification of direction of ground water flow which affect recharge system in the basin.

- Fundamental hydrogelogiccal information
- Estimation of the ground water flow to this direction
- EC depth profiling
- Basement depth

(12) F014 Ankoba-Mikazy

1) Location map

Site location is eastern central of Ambovombe basin, about middle of F009 and P008Betsioki. Access can be reached both from Ambovombe and Ifotaka. It would be possible to access even during rain season .



Notes: one section is 100m

2) Hydrogeological condition

The site is located at the transient zone between the basin and the eastern horst. Unconsolidated sand is expected from surface and may change to the sandstone in the view of topography.

- Gentle slope
- Foot of horst which lies between river Mandrare and Ambovombe
- Unconsolidated sand
- agriculture activity

3) Information to identify the points

- Point is in a fallow field between the entrance to village and the houses
- Current water source is Mandrare river near Ifotaka.
- Village is a base for grazing. Origin of village people is Ambovombe

4) important observation during drilling

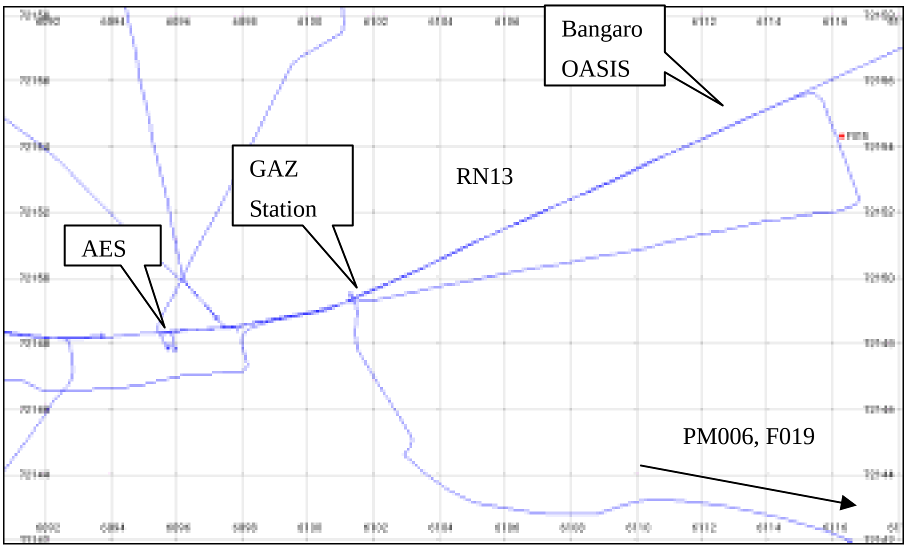
This area is expected a transient zone between sandstone of neogene and sediment area. It is important to collect information of depth of basement (or impermeable formation) and aquifer structure to identify direction of ground water flow which affect recharge system in the basin.

- Fundamental hydrogelogiccal information
- Basement depth
- Estimation of the ground water flow to this direction
- EC depth profiling

(13) F015 Mangarivitra Tananbao（Cu Ambovome）

1) Location map

Site location is at the eastern edge where houses of Ambovombe begin along the RN13. The land is not yet farmed, but already lined with cactus.



Notes: one section is 200m

2) Hydrogeological condition

The site is located at the on the eastern end of Ambovombe plateau. There is a depression at the north and the south, while altitude increase to the east. Unconsolidated sand is expected. The result might be similar to the result of “FERME AMBOVOMBE” reported by AUROZE

- same plateau as Ambovombe
- Unconsolidated sand
- Borehole FERME AMBOVOMBE

3) Information to identify the points

- The land is private land
- Unexploited land
- Divided by cactus

4) Important observation during drilling

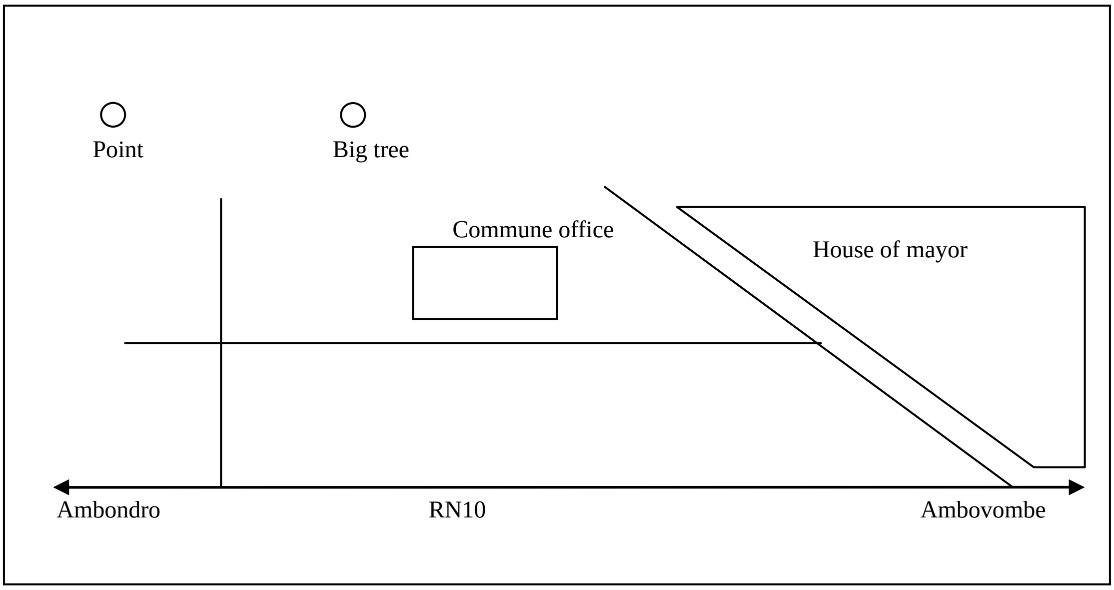
This point is a candidate as water source to supply water to Ambovombe referring the existing data of FERME AMBOVOME. Salinity of water is the important criteria as a water source, so change of salinity must be carefully observed with identification of aquifer.

- Fundamental hydrogelogiccal information
- EC depth profiling
- Basement depth

(14) F018 Ambanisalika

1) Location map

Site location is just 50m to north from the office of commune Ambanisalika.



Notes: no scale

2) Hydrogeological condition of village

The site is located near the boundary of the Ambovombe Basin. No water source exists in the surroundings. VES results indicate an existence of high resistivity zone shallower than 50m. If water exists, this zone might be fresh water. Unconsolidated sand is expected.

- High resistivity zone shallower 50m
- Unconsolidated sand is expected
- No shallow well

3) Information to identify the points

- Beside office of commune
- Beside house of mayor

4) Important observation during drilling

This point is a candidate as water source to supply water to Ambovombe in the view of topography. Altitude is higher than basin, so that water might be not to be contaminated with salinity like the bottom of basin if aquifer exists. Salinity of water is the criteria as water source, so change of salinity must be carefully observed with identification of aquifer.

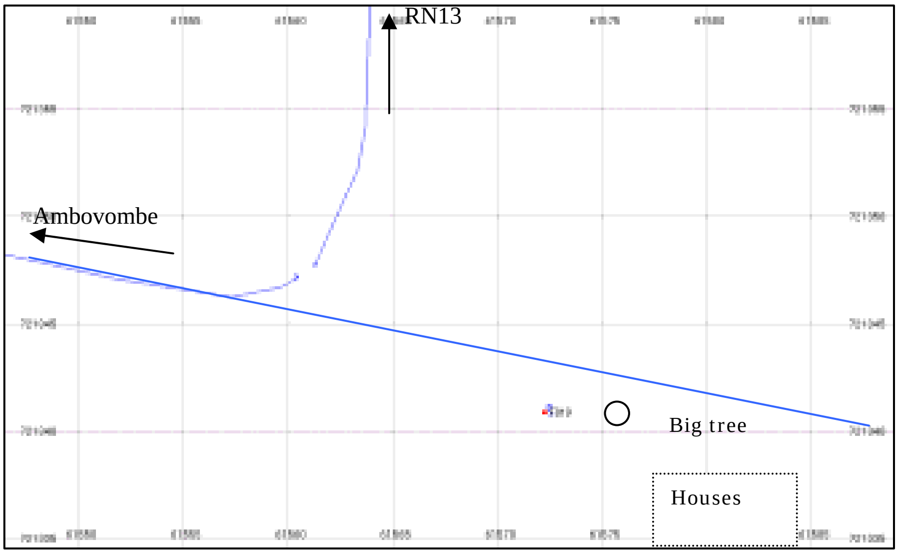
In addition to that, it needs to confirm existence of aquifer at 50m depth.

- Fundamental hydrogelogiccal information
- Existence of aquifer at 50m depth
- EC depth profiling
- Basement depth

(15) F019 Ambazozmirafy

1) Location Map

Village is situated at the ridge of the coastal dune, which is the most inner among three dunes. The village can be accessed from Ambovombe in the south-eastern direction passing through PM006 along major route.



Notes: one section is 50m

2) Hydrogeological condition

Village is situated on the ridge of the coastal dune, which is the most inner among three dunes. Geology might be unconsolidated sand. This area is the eastern of fracture.

- ridge of the coastal dune
- Unconsolidated sand is expected
- The eastern of fracture

3) Information to identify the points

- 6km from center of the Ambovombe
- 5km from water source in Ambovombe

4) Important observation during drilling

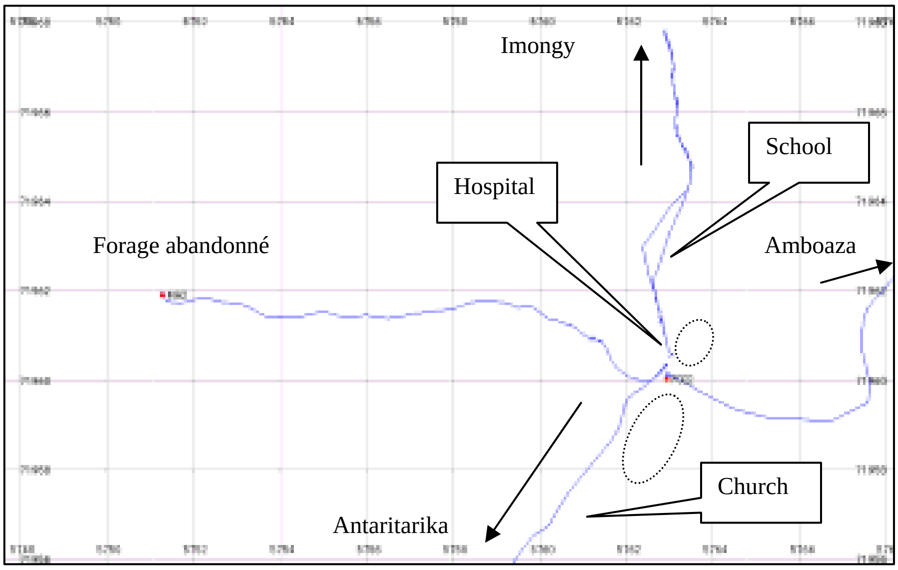
This point is a candidate as water source to supply water to Ambovombe in the view of topography. if aquifer exists. Chance is in case impermeable layer exist in the dune. Other interest is to know if there is ground water flow to the see along the edge of fracture because drainage of groundwater from basin is unknown.

- Fundamental hydrogelogiccal information
- Basement depth

(16) F022 Anjira

1) Location map

Village is situated in the valley of the first and second coastal dunes. The point is selected in the village at the junction of toads to Imongy, Antaritarika and Ambazoa,



Notes: one section is 200m

2) Hydrogeological condition of village

Village is situated in the valley of the first and second coastal dunes. Geology might be unconsolidated sand and clay-limestone. .Outcrop of clay-limestone is observed at the slope of the southern dune. There was one borehole constructed in 1967 1.2km away to west. and was used until 1972. Water was little bit salty.

- clay-limestone or unconsolidated sand
- One borehole existed but little bit salty.
- The NS is around 30m and depth is 75m
- GPS elevation is 77-80m. So that, 78 – 7.2(sea level) = 70.8m. Water level must be higher than this.
- The reason of abundant is no spare parts of pump.

3) Information to identify the points

- Villagers draw water at the Mananbovo river.
- Village people used fairly salty water of borehole for 10 years.
- Point is in the village at a junction of Imongy, Ambazoa, Antaritarika
- There is a hospital and a school.
-

4) Important observation during drilling

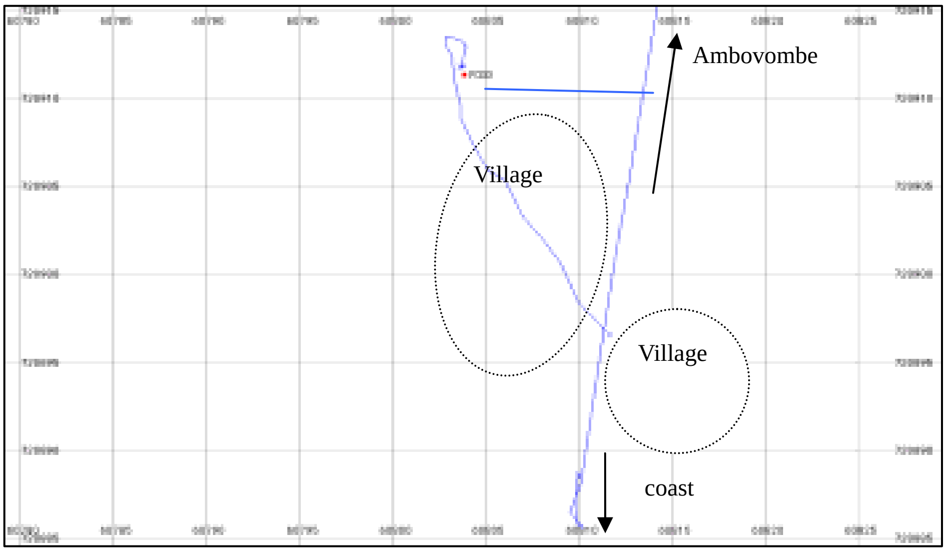
This point can be a model case as water source at the western coastal dune. Water supply with hand pump is candidate because demand to fairly salty water is not clear.

- Fundamental hydrogelogiccal information
- Salinity profiling
- Basement depth

<u>(17) F030 Ekonka</u>

1) LOCATION MAP

Village is situated in the valley of the first and second coastal dunes. but altitude is not so low.



Notes: one section is 200m

2) Hydrogeological condition

Village is situated in the valley of the first and second coastal dunes. Geology might be unconsolidated sand and clay-limestone. This area is the western end of fracture, and depth of basement is expected the deepest according to interpretation of VES. Ground water flow which is equivalent to amount of the expected recharge is not found. One possible assumption is eccentric distribution along the western edge of graven if proper structure exists.

- Coastal dune
- Unconsolidated sand and clay-limestone.
- VES result indicate the deepest basement

3) Information to identify the points

- Northern part of village.
- Cleared land
- Village people draw water at Ambovombe

4) Important observation during drilling

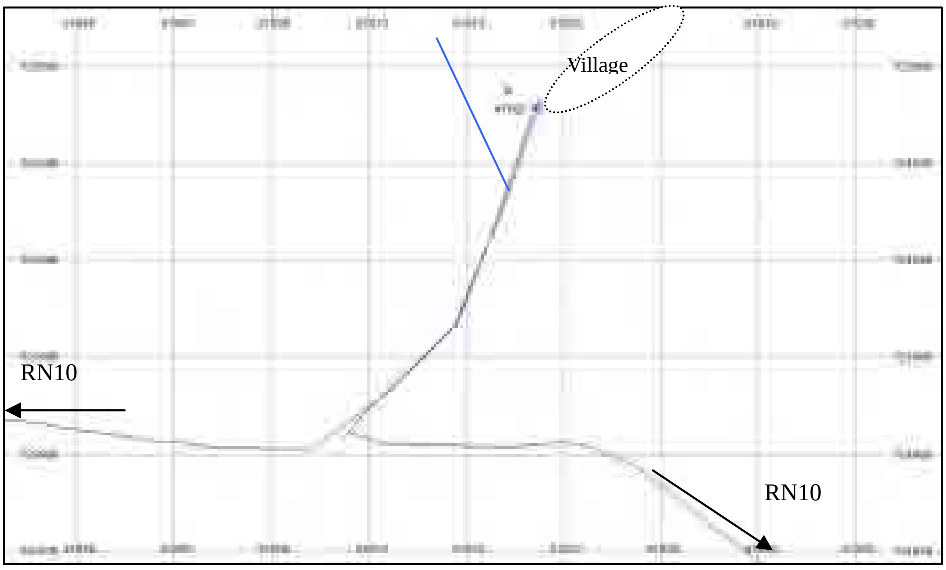
This point is a candidate as water source to supply to coastal area in the view of topography. if aquifer exists. Chance is in case impermeable layer exist in the dune. Other interest is to know if there is ground water flow to the see along the edge of graven because drainage of ground water from basin is unknown.

- Fundamental hydrogelogiccal information
- Basement depth
- Check existence of aquifer at 0m altitude

<u>(18) F032 Behabobo</u>

1) Location map

Village is situated at the slope of the hill between Ambovombe and Amboasary.



Notes: one section is 50m

2) Hydrogeological condition

The body of hill might be sandstone and mudstone. The outcrop of the sand stone is observed at the coast of Maroalomainty. The ground water might flow along direction of the valleys which are parallel to ridge of hill if geology is not permeable.

- Hill
- Slope
- Sandstone

3) Information to identify the points

- In the village
- Village people draw water to Ambovombe

4) Important observation during drilling

This point is a candidate as water source to supply water to Ambovombe in the view of topography. if aquifer exists. Chance is in case impermeable layer exist. Other interest is to know static water gradient to create model ground water flow.

- Fundamental hydrogelogiccal information
- Basement depth
- Depth of aquifer
- Permeability of formation

DP2.6 Test Drilling Analysis

DP2.6.1. FM001

The objective of this site was to figure out the aquifer just above the sea level in this area. If this site is proved to be successful, the new well could shorten the distance of collecting water compared to the current location at the seacoast. At an altitude of 90 m, the final depth of the well being 100m corresponds to an altitude of -10 m.
The result indicates negative character of aquifer. The aquifer actually existed near the sea water level, but had very high salinity content, which was much higher than the well along the coast. Village people also commented that the water was not suitable for drinking usage. As a result, this test well was not selected as a pilot site, but temporal water sampler was provided to the villagers to confirm validity as secondary water.

(1) Geology
1) Cutting observation
The geology is rather uniform and shows fairly consolidated dune sand with fine sand which resembles sea sand. The formation contains calcareous particles throughout the whole formation. This indicates that the sand is not transported and deposited by wind. Other special remark is that ilmenite is contained from 55m to 74m.

2) Logging
Mostly, the value of 64N is higher than 16N, which proves impermeability of formation. This reinforces the observation of formation which is well consolidated. Degree of consolidation might be related to the resistivity, especially at depth 30m-40m.

<table>
<tr><th colspan="2">Depth (m)</th><th>Resistivity</th><th>estimated state of geology</th><th colspan="2">Comparison with VES W188, the point situated several km away to the north, 30m difference of altitude. The altitude is not well adjusted.</th></tr>
<tr><td>0</td><td>30</td><td>50 to 70, increasing gradually</td><td>Calcareous sand is fairly consolidated, Degree of consolidation increase gradually deeper.</td><td>400-120</td><td rowspan="2">High resistivity near surface was expected causing air in the porous formation, but, it can be interpreted as degree of consolidation or containing calcium by formation logging.</td></tr>
<tr><td>30</td><td>40</td><td>200</td><td>As degree of calcium increases, hardness of consolidated calcareous sand is getting like rock.</td><td>120-310</td></tr>
<tr><td>40</td><td>55</td><td>100</td><td>Decreasing degree of calcium, degree of consolidation is lowered.</td><td>15</td><td rowspan="4">Deeper formation is not possible to be separated with VES, but, is possible to distinguish from upper consolidated sand.</td></tr>
<tr><td>55</td><td>65</td><td>100 to40 decreasing gradually</td><td>Degree of calcium continue to lower</td><td>15</td></tr>
<tr><td>65</td><td>78</td><td>40</td><td>Degree of consolidation is lowered due to humidity of groundwater.</td><td>15</td></tr>
<tr><td>78</td><td>TD</td><td>10</td><td>SWL is about 80m, the aquifer surrounded is water saturated with ground water.</td><td>15</td></tr>
</table>

(2) Completion
The casing screens were installed at shallower part, but, water inflows at only bottom screen. The development was executed intermittently with 30minutes interval because water nearly dried up 30 minutes later. Each time water was poured into well to make enable airlift. Conductivity changed from 13,000 to 17,000μS/cm in the end.
(3) Pumping Test
・ 5 steps were executed, but each step was terminated after 305minutes, 140minutes, 65minutes, 55minutes and 38minutes because dynamic water level reached to the pump.

- Total pumped volume of water at each step was ranged from around 1,000L to1,300L, while the volume of the casing is about 131L. Although the yield was very little, water production from formation was confirmed by this test.
- Water column was less than 10m thick.
- EC had increased for 1,000µS/cm at the end of test. The aquifer might have gradient within short interval.

(4) Evaluation

- EC was as high as 26,000µS/cm, but it might not be directly connected to the sea water due to very low permeability.
- Formation was consisted of sand deposit, but permeability was not so high.
- Mud loss was not seriously encountered. This also supports lower permeability of formation and sand is consolidated with calcium and silt.
- The existence of aquifer of which the level is the same as sea level was confirmed.
- Fresh ground water flow does not exist near seacoast. The percolated rainwater is well mineralized before reaching to the aquifer.

DP2.6.2. PM 005

The objective of this site was to recognize the prolongation of the perched aquifer of Ambovombe. At an altitude of 186 m, the final depth of this well being 80 m corresponds to the altitude of +106 m, which is about fifteen meters under the average depth of the aquifer of Ambovombe. In general, grey clay formation exists at the bottom of aquifer in the nearest shallow well field from this site. During drilling, apparent clay formation was not observed. Although we didn’t drill out bottom of perched aquifer, we couldn’t find groundwater at the same or higher altitude of the one in the Ambovombe. This reveals that the continuous recharge to the Bevory area from the southern dune does not exist.

(1) Geology

1) Cutting observation

The geology is rather uniform and shows dune sand with fine beige color. Two layers of slightly argillaceous with brown red were confirmed from the surface down to 13 m and also between 50 and 65 m. Calcareous sand lay from surface to 48m with certain interval of limestone-like layer. Its permeability seems to be very low due to consolidation.

2) Logging

Indication of certain thin resistive formations is encountered. Probably some degree of cemented sand affects change in resistivity. Porous layer including air was presumed around 18-40m, but on the contrary, the formation was consolidated by calcium and formed hard block. The lower resistivity formation indicates little content of calcium and less consolidation.

depth		resistivity	Geology	Comparison with VES,W014,300mto the east, altitude is 115m, little difference and no compensation for comparison.	
0	17	Above mud	Highly weathered calcareous sand	40-145	VES indicates highly weathered unconsolidated status. That matches actual state.
17	22	70	Calcareous sand, nearly limestone	28	Result indicates much lower resistivity than actual one. Characteristic result which is lower resistivity comparing upper formation, is reliable.
22	38	50	Calcareous sand, consolidated with calcium	28	
38	41	80	Calcareous sand, consolidated with calcium	28	
41	53	20	Decreasing degree of calcium, degree of consolidation is lowered.	7	Far from actual characters. Analysis was mislead by the unreliable deeper data.
53	57	40	Bit higher degree of consolidation and calcium	7	
57	80	15	Decreasing degree of calcium, degree of consolidation is lowered.	7	

(2) Completion

The borehole was equipped with screen in the bottom and also high resistive zones set between depths 74.4 and 80.0 m and from 29.4 to 40.7.

The development was conducted intermittently with 30minutes interval for 6hours because water nearly dried up immediately after start. Each time 2m^3 of water was poured into the well to make enable airlift. However, in spite of 6hours of development, the well did not yield water. Conductivity hadn’t changed from around 2,540 μS/m from beginning to the end.

(3) Pumping Test

Pumping test was not executed because the well was dry.

(4) Evaluation

The objective of drilling was to find any retention layer like the aquifer of Ambovombe under the altitude of 120 m. Drilling was executed until the altitude 106 m (106m = 186m – 80m) without appearance of retention layer at the distance of 3 km away from the urban area. We can conclude that the sand aquifer formation does not have a sufficiently horizontal extension of impermeable argillaceous from Ambovombe. The rainwater infiltrations might percolate into deeper aquifer at the south-western part of Ambovombe and does not recharge shallower aquifer.

DP2.6.3. PM 006

Objective of this test well PM 006 was to identify perched aquifer in the dunes of the south of Ambovombe, which was expected as a prolongation from the aquifer in the urban area or the recharge to Ambovombe.

The 50 m depth at altitude 178 m might reach to the shallowest aquifer at Ambovombe (+ 120 m).

The result indicated no appearance of groundwater, so that, the prolongation nor recharge does not exit here.

(1) Geology

1) Cutting observation

Cuttings show rather uniform and fine sand rather red argillaceous up to 19 m of depth, then brown yellow not-very argillaceous beneath. The reddish color section reflects penetration of oxidation. Yellow part may well be consolidated suppressing porosity between grains. Calcareous sand starts at 50m.

2) Logging

Certain higher resistive formation might indicate a state of higher degree of consolidated sand, including air. This state is reflected as mud loss did not occur during drilling although cutting was just sand.

depth		resistivity	Geology	Comparison with VES,W101,230mto the north-east, altitude is 146m, 10m difference and no compensation for comparison.	
0	9	Above mud	Highly weathered sand with clay/silt	160	Highly weathered sand with clay/silt including air between grain
9	12	30	Highly weathered sand with clay/silt	64	Some of a few meters consolidated thin layers interbed. VES can't resolve thin layers because of thickness and low contrast In general, sand is consolidated with certain degree, then it was interpreted as higher resistivity. Value itself is affected by lower formation.
12	14	100	Sand with little clay	64	
14	20	50	Highly weathered sand with clay/silt	64	
20	24	100	Sand with little clay, degree of consolidation is higher because N16 value is higher than N64	64	
24	39	50	Sand with little clay, degree of consolidation is lower	64	
39	40	100	Sand with little clay, degree of consolidation is higher because N16 value is higher than N64	64	
40	51	50	Sand with little clay, degree of consolidation is lower	64	

(2) Completion

Screen was installed at the bottom between the depths 46.5 m and 49.3 m to expect aquifer, which is prolongation from Ambovombe.

Development after cleaning of the mud, but no water was lifted.

The development was executed intermittently with 20minutes interval for 4hours because water nearly dried up immediately after start. Each time 2 to 3m^3 of water was poured into well at 5 times to make enable airlift. However, in spite of 4hours of development, the well did not yield water. Conductivity didn't change from around 1,580 µS/cm from the beginning to the end.

(3) Pumping Test

It was not executed due to dry well.

(4) Evaluation

The sand formation does not have a sufficiently horizontal extension of perched aquifer of Ambovombe.

In general, grey clay formation exists at the bottom of aquifer in the nearest shallow well field from this site. During drilling, apparent clay formation was not observed. Although we didn't drill out the bottom of perched aquifer, we couldn't find groundwater at the same or higher altitude of the one in the Ambovombe. This reveals that the continuous recharge to the AMBARO, ESTINGO area from the southern dune does not exist. The rainwater infiltrations might percolate until deep aquifer.

DP2.6.4. F 001

Objective of test well F001 is to appraise productivity of that was expected ideal water quality for certain investment such as pipeline construction to Ambovombe. The reason of selection is that water quality around this area is relatively good and the observed lineaments in the aero photo intersect at this area.

Yield is relatively large as a fracture type at the hard rock, and can adapt to a small scale water supply system (1000-2000 habitants), but electric conductivity is little bit higher than expected.

(1) Geology

1) Cutting observation
Metamorphic rock is dominated by quartzite, sandstone and migmatite. Geology varies in the view of type and degree of weathering at different depth. Variety of geology reveals complex tectonic process at this area which creates a lot of fractures in the hard rock.

2) Logging
In general, interpretation of resistivity log for hard rock is difficult, but the results match with the state of geology at this point.

<table>
<tr><th colspan="2">Depth</th><th>Resistivity</th><th>Geology</th><th colspan="2">Comparison with VES,W040,1000m to the north, altitude is 308m, 10m difference and no compensation for comparison.</th></tr>
<tr><td>0</td><td>20</td><td>Above mud</td><td>Highly weathered several type of rocks interbed.</td><td>256</td><td>Highly weathered and transformed clay/silt revealing relatively lower resistivity。</td></tr>
<tr><td>20</td><td>24</td><td>200</td><td>Several types of rocks interbed with thin interval. Weak weathering and fissure on the rock.</td><td>660</td><td rowspan="6">Resistivity structure is interpreted as an averaged mass resistivity structure, because the fractures don ’ t continue thought structure. Fractured structure of 65m-80m can’t be distinguished because of low contrast of resistivity.</td></tr>
<tr><td>24</td><td>44</td><td>600</td><td>Quartzite under apparent weathered zone. Fracture exists with certain frequency.</td><td>660</td></tr>
<tr><td>44</td><td>45</td><td>800</td><td>Quartzite with few fracture</td><td>660</td></tr>
<tr><td>45</td><td>58</td><td>300</td><td>Quartzite under apparent weathered zone. Fractures exist with certain frequency.</td><td>660</td></tr>
<tr><td>58</td><td>68</td><td>300-1000, 500 thin layered fractured intervals with large resistivity contrast</td><td>Migmatie with several intermittent fractured zone</td><td>660</td></tr>
<tr><td>68</td><td>80</td><td>1000、500 thin layered fractured intervals with large resistivity contrast</td><td>Migmatie with several intermittent fractured zone, Density of fracture is reduced.</td><td>660</td></tr>
</table>

(2) Completion
The screen was installed targeting 2 separate highly weathered zone, each interval is about 20m, salinity increasing gradually as it gets deeper.
Development was executed for 5 hours, water quality and yield were stabilized after 90 minutes and 3hours, respectively.

(3) Pumping Test
Drawdown curve of constant long duration changes unevenly. This means that the aquifer is divided into several compartments or connecting with a channel. Referring to the information of geology and the change in water quality, the aquifer can be considered to be consisted of two major parts. Exceeding $7m^3/h$ of pumping rate, dynamic water level drastically start lower, so that, hydro geological coefficient of the upper part shall be employed to evaluate this well in the view of safe margin.

(4) Evaluation
Extension of low conductive ground water zone was confirmed that it spreads from the urban area of Antanimora to the south, as the distribution of conductivity of existing wells reveal. On the contrary to the expectations, the conductivity of this well was much higher than the water source of the urban area. If better quality of water is required, it is better to explore at the northern part of the urban Antanimora.
The yield is much higher as an aquifer in the hard rock. Large yield might cause of a lot of fractures which was generated by intersection of the fracture belt. Aero-photograph analysis might be effective regarding lineament detection.

DP2.6.5. F 006

Objective of test well F006 is to appraise productivity of that was expected ideal water quality for certain investment such as pipeline construction to Ambovombe. In the view of parameters like quantity, quality, and distance to Ambovombe, favorable locations are justified. The sites are located along the Bemamba river, where the flowing direction change to the east from the south east in this area.
The result is preferable although hard rock starts 15m in the view of quantity and quality.

(1) Geology

1) Cutting observation
Sand alluvium overlays 15m deep above the basement rock. Aquifers are at the highly weathered and fractured hard rock. Various types of rocks were encountered such as leptytite, pegmatite and schist. This area might be located at the fault band as topography indicates lineament and river.

2) Logging

<table>
<tr><th colspan="2">Depth</th><th>Resistivity</th><th>Geology</th><th colspan="2">Comparison with VES,W084,3000m to the north, altitude is 254m, 15m higher and no compensation for comparison.
W035 is situated at the same distance to the south east, but it is not suitable for comparison because resistivity is lower at the whole depth and hard rock is not detected.</th></tr>
<tr><td>0</td><td>22</td><td>Above mud</td><td>Sediment sand</td><td>330-120-29</td><td>Highly weathered and transformed clay/silt revealing relatively lower resistivity.</td></tr>
<tr><td>22</td><td>52</td><td>100</td><td>Weathered schist and leptytite including mica. Fracture is well developed.</td><td>29-260</td><td rowspan="4">Relatively lower resistivity reflects higher density of fractures.
Certain thickness of higher resistivity zone exist at 52-58m, but that is not distinguished as independent formation. The zone is interpreted as continuous structure with lower resistivity.</td></tr>
<tr><td>52</td><td>58</td><td>300</td><td>Schist and leptytnte including mica with little fracture and sill of quarts.</td><td>260</td></tr>
<tr><td>58</td><td>66</td><td>200</td><td>Leptynite and amphibolite, blue and green colored. Little fractures.</td><td>260</td></tr>
<tr><td>66</td><td>78</td><td>250</td><td>Leptynite and amphibolite, blue and green colored. Frequency of fractures is decreased.</td><td>260</td></tr>
</table>

(2) Completion
Casing screen was set to whole section except the higher resistive interval.
The well was cleaned 2 hours later since the air lift started. Water quantity was enough to wash out debris from borehole rapidly.

(3) Pumping Test
The slop of the draw down curve change and reveal water migrate from different trasnmisive aquifers.
Bemamba river recharge alluvium and weathered formation along the river, then ground water is stored with certain scale near surface. That gives a recharge characteristic at the drawdown curve.

(4) Evaluation
The well capacity is enough as source for conducting water to Ambovombe in the aspects of water quality and quantity. Uncertainty is that saline water flow down from the surroundings. Comparing F006B where is located to the west, salinity is half of that. Recharge along Bemamba river is expected huge enough, but Water balance is needed be considered because water quality of surroundings area higher than 1,000 μS/cm.

Clarified characters are

- Lower conductivity aquifer was confirmed as existing data reveal.
- Major aquifer is a weathered hard rock, while Manave where is several km away to the south, is

sand formation. Between them, depth of basement rock rapidly declines.

- 20-30m3/h of similar yield is confirmed with another complementary test well which is 2.3km away to west.

DP2.6.6. F006B

Objective of test well F006B is to appraise productivity of that around F006 for certain investment such as pipeline construction to Ambovombe. The location is about 2300m to the west near RN13.
The yield is similar to the F006, but slightly lower transmissivity and higher salinity(EC=1,250 μ S/cm).

(5) Geology

1) Cutting observation
Sand alluvium overburden 5m depth above basement rock. This thickness is much thinner compare to the F006. Aquifers are at the highly fractured hard rock. Various type of rocks was encountered like leptytite, pegmatite, schist. A crushed zone by fault band still continues to this area from the Bemamba river.

2) Logging

Depth		Resistivity	Geology	Comparison with VES,W084,3000m to the north, altitude is 254m, 5m higher and no compensation for comparison.	
0	14	Above mud	Sediment sand	330-120-29	Highly weathered and transformed clay/silt, typical high-low structure of the weathered layer of hard rock.
14	26	200-250	Well weathered leptytite.	29	Since location is different, low structure is not observed by the resistivity logging
26	43	250	Gneiss and quarts	260	Since location is different, the separation is not observed between the fractured zone of 43m and not fractured zone
43	60	250 with 50 of a few meter of thin layers	Gneiss well fractured	260	
60	62	150	Gneiss well fractured with significant fracture. Yield during frilling changes.	260	
62	64	200	Continuation of upper later, but, measurement is not well done due to sensor configuration.	260	

(6) Completion
Casing screen was set at the whole section of fractures.
The well was cleaned 2 hours after the air lift started. Water quantity was enough to wash out debris from borehole rapidly.

(7) Pumping Test
The slope of the draw down curve change and reveal that water migrate from different transmissive aquifers.
Bemamba River recharge alluvium and weathered formation along the river, then groundwater is stored with certain scale near the surface. That gives a recharge characteristic at the drawdown curve.

Drawdown curve becomes flat as time passes. Groundwater might be stored in the weather zone and supply to deep fractured aquifer.

Compared with F006, EC is much higher as it showed 1,250μS/cm. Groundwater from hard rock might affect and increase conductivity of water.

(8) Evaluation

The well capacity is enough as source for conducting water to Ambovombe in the aspects of water quantity. However, electric conductivity is little bit high as 1,250μS/cm,, therefore there is possibility of migration of higher conductive water from the surroundings.
It is better to develop ground water near Bemamba River for pipeline project.

Clarified characteristics are

- Conductivity of aquifer is higher than near Bemamba River.
- 20-30m3/h of yield is confirmed around this area.

DP2.6.7. F009

Objective of test well F009 is to confirm depth of basement and groundwater gradient to the east.
Hard rock starts 78m and covered by alluvium which contains gravel of marble and silt rather than sand. Formation is impermeable, almost dry and static water level is very deep as 61.6m at June 2006 while 48.4m at the time of pumping test.
Groundwater doesn't flow out to the east in general and static water level is nearly similar to Ambovombe and different from the area of F006

(1) Geology

1) Cutting observation

Sand formation overlays above basement rock, but sand formation are including much silt and non-quarts grains. At deeper than 63m, angular 10-20mm gravel made of several type geology are deposited in the silt-sand. Formation is consolidated with silt, not calcium. Material react to the acid chloride is marble called as CIPOLIN.

2) Logging

Depth		Resistivity	Geology	Comparison with VES,W037,4000m to the west, altitude is 168m, 10m lower and no compensation for comparison.	
0	12	Above mud	Oxidized sand sediments	9-3-9	Resistivity is much lower than its looks
12	18	60	Oxidized sand sediments	9	VES interpreted as very low resistivity formation, but, actually not. But, low contrast of layers are well interpreted.
18	19	40	Oxidized sand sediments, but size of grain might change bigger. There is no factor to rise resistivity since the mud resistivity is 2Ω	9	
19	30	30	Sand, silt	9	
30	32	20	Sand, silt、hole diameter might enlarge due to lower consolidation	9	
32	40	30	Sand, silt. Sand is superior relatively.	9	
40	80	10	Sand, silt. Silt is superior relatively.	34	Detected value is not valid anymore due to low resistive formation.

(2) Completion

Casing was installed up to 78m above hard rock. Screen was installed at certain lower resistive formation, but no groundwater may not exist.
The development was executed intermittently with 40minutes to 50 minutes interval with 20 minutes halting for 6 hours because water nearly dried up immediately after start. Yield was less than 0.1m3/hour

and conductivity increased from 2,030μS/cm to 2,820μS/cm at the end. Water level kept rising 3 m for 4 hours after terminating airlift.

(3) Pumping Test
Analysis of step drawdown test is not possible because yield is too little and water level reaches to the pump rapidly. The pumped quantity was 100-160L at any pumping rate. Inflow from aquifer might be limited.
Recovery took 15 times of time as pumping time. This also indicates scarce inflow from aquifer.

(4) Evaluation
Formation is consisted of sediments, but is well consolidated with silt, then its characteristic is low permeability and low resistivity. The result of VES is similar around this area. This indicates groundwater flow is scarce around this zone. High conductivity of groundwater results of low permeability.

DP2.6.8 F014

The objective of the test well F014 is to test the potential of groundwater as a drinking water source, and also to find the depth of the basement and static water level in the unexplored area. This site is fairly important because this site allows supplying water to the urban area of Ambovombe by gravity.
The result was negative for water supply, as EC was 10,000μS/cm, and the static water level was as deep as 100m. Geology resembles to that of the coastal dune.

(1) Geology

1) Cutting observation
Sand/Sandstone or calcareous sandstone continues to the bottom of the borehole. Neither hard rock nor mudstone was encountered although this area was expected as a horst. The change of geology as calcareous wasn't observed until 67m, while calcareous sand dominates from 68m. Top layer of calcareous sand is oxidized and colored reddish, which means, that the sedimentation was once halted at this depth. Ilmenite which is black colored and very tiny grain exists through the whole formation.
The size of the grain is generally fine to very fine (>0.5mm), but, relatively big grain (1mm) sand was seen at 101-103m.
During drilling, mud resistivity decreased to 2,000 μS/cm at 20-40 m which might be a sign of shallow aquifer.

2) Logging

Resistivity structure coincides with result of VES. Sand formation and Calcareous sand formation is clearly separated.

Depth		Resistivity	Geology	Comparison with VES,W028, 3100m to the east, altitude is 181m, is equal. No compensation for comparison.	
0	12	Above mud	Oxidized sand deposit	650-57	Upper sand is very loose and contains air between grain, then resistivity is high, but, consolidation starts a few meter beneath.
12	45	100 with fluctuation	Sand, probably, partially degree of consolidation change, then borehole diameter change and affect resistivity.	57	Existence thin layer and absolute value don ’ t coincide , but general resistivity structure coincide.
45	50	150	Sand, no particular reason of higher resistivity	57	
50	65	100-30	Sand, Response sound like a transition zone to low resistivity formation underneath, but, geologically, formation character suddenly changes at 67m in the view of existence of calcareous sand.	57-18	
65	120	30	Calcareous sand. Although strongly consolidated like rock, but resistivity is low. Salinity might be contained.	18	

(2) Completion

The cutting didn’t indicate apparent retention of water. The screen was installed from 41.32 to 49.75 and from 91.9m to 120m, where the coarse sand dominates. However, upper part of screen doesn’t contribute because water level should be much lower than that.

The development was executed intermittently with about 30 minutes interval with 30 minutes halting for 5 hours 15 minutes because the water nearly dried up immediately after the start. The yield was stabilized as mud was cleared from the borehole. Eventually, a yield of 2.18m3/hour with 5040 µS/cm was gained in the end.

(3) Pumping Test

Drawdown curve show complex structure of aquifer as curve change its slope twice. This might be caused by the existence of different hydraulic characteristic aquifers or by that the extension of equal characteristic is limited.

(4) Evaluation

The aquifer was confirmed, but did not have good permeability and had high salinity, which is not suitable for drinking. Static water level is about + 81m. This groundwater level is higher than water level of the *Vovo*s at Ambovombe, This area doesn’t contribute recharging shallow aquifer of Ambovombe, while, this area can recharge high salinity water to the deeper aquifer.

DP2.6.9 F015

The objective of F015 is to test the deep aquifer being at the altitude around the sea level. The potential of quantity was confirmed, but, water quality is salty. However, it still satisfies peoples’ requirement in this region because the water quality of the existing water source isn’t any better and also the quantity doesn’t satisfy requirement.

(2) Geology

1) Cutting observation

The cutting indicates argillaceous nature and includes calcareous sand; relatively geology is uniform to the bottom. The geologic characteristics resemble to the one of coastal boreholes.

2) Logging

The coarser sand layers were confirmed by the resistivity log except the bottom, otherwise the logs indicate a finer grain. Resistivity drops to 10Ωm at the aquifer show strong contrast with upper formation. The structure interpreted by VES is also similar structure.

<table>
<tr><th colspan="2">Depth</th><th>Resistivity</th><th>Geology</th><th colspan="2">Comparison with VES,W181, 200m to the north west, altitude is 186m, is equal. No compensation for comparison.</th></tr>
<tr><td>0</td><td>25</td><td>Above mud</td><td>Oxidized deposit sand</td><td>315-51</td><td>Upper sand is very loose and contains air between grains, then resistivity is high, but, consolidation starts a few meter beneath.</td></tr>
<tr><td>25</td><td>65</td><td>10 -70 gradually increasing</td><td>Calcareous sand, consolidated</td><td>124</td><td rowspan="3">Three type of formations are not distinguished. One change resistivity gradually in the 40m thickness, one is thin layer of 100Ωm with 10m thickness, last is 70Ωm with 50m thickness</td></tr>
<tr><td>65</td><td>75</td><td>100</td><td>Calcareous sand, consolidated</td><td>124</td></tr>
<tr><td>75</td><td>125</td><td>70</td><td>Calcareous sand, consolidated
Calcareous sand is not significant between 80-97m</td><td>124</td></tr>
<tr><td>125</td><td>132</td><td>90</td><td>Sand</td><td>24</td><td rowspan="2">Low resistivity structure matches with the result of logging</td></tr>
<tr><td>132</td><td>150</td><td>10</td><td>Sand, colored grayish, probably affected by existence of water</td><td>24</td></tr>
</table>

(3) Completion

The cutting didn't indicate apparent interval of retention of water. The screen was installed between 120.8 and 148.9 m and between 73.1 and 78.7 m where coarser sand exist refering to the cutting and the logging The development lasted ten hours, approximately 1.5 m^3/h clear water came out from the beginning to the end. Yield is small because static water level is too deep to lift by air. Conductivity reached 4 600 μ S/cm 25 ° C at the end of the cleaning. The residents near sites benefited and draw water with the buckets during airlifting.

(4) Pumping Test

The first pumping test was carried out on November 15 with a pump having capacity of 2.25 m3/h. The drawdown was stabilized at 0.13 m at the end of 3 hours. Pumping was terminated because it needed more powerful pump to test its characteristics.

The second test was executed on the 20 and 21 December for 24 hours with a pumping rate of 7.6 m^3/h. Drawdown was nearly stabilized at 0.38 m just after few minutes. The water level was not stabilized completely and kept lower little by little as time passed. At the end of 24 hours test, the drawdown showed 0.43 m, with 7.17 m^3/h/m of the specific yield. Pump capacity was still too small to identify characteristics of the aquifer at the greater pumping rate.

Conductivity was much smaller than the expected. This was probably due to the good permeability of aquifer compared to the higher salinity aquifer.

(5) Evaluation

1) Clarified characteristics

① Quality of water

The conductivity of water reached 4 600 μ S/cm 25° C during the development. During the first test of pumping to 2.25 m3/h it fell quickly to 3 000 μ S/cm which retained the limit of portability in the South of

Madagascar.
During the test at 7.6 m^3/h of discharge, it remained constant around 3,060 μ S/cm 25° C. the temperature was 28.7 °C and pH of 7.65.

Mineralization clearly exceeds the limit of portability according to the standards of the UE or WHO. But the quality of the F015 can be regarded as relatively good for the area, except some fresh water wells of Ambovombe. Groundwater of the area presents larger mineralization of the same magnitude or often higher than that of the F015.
Water of conductivity higher than 3 000 μ S/cm is usually used for the human consumption. In addition, even higher conductive water can be used for the domestic needs and the animal feeds (the zebu drink water of higher than 16 000 μ S/cm 25° C – at coast in particular).

② Yield
The results of drilling present very interesting fact for this area in the view of yield, which were 18 m^3/h/m. This will satisfy the requirement of water amount for the urban of Ambovombe, which is approximately 35-50 m^3/h. According to the first result, F015 could cover partly or entirely these needs.

2) Raised question and assumption
- Would the water quality remain the same even if water is pumped continuously?
- The tested pumping rate is much smaller than the targeted rate. Can yield and water quality stabilize at the targeted yield?
- These results shall be confirmed by a test of long duration (at least estimated amount by simulation) regarding water balance and salinity intrusion. This test must be carried out with a more significant discharge of about 30 m^3/h.

DP2.6.10 F 018

The survey objective is to recognize the depth of basement and to identify aquifer. In the event of success: water supply system can be proposed for commune (Ambanisarika) and gravity feed system to Ambovombe at relatively short distance (11 km).
The borehole didn't reach to the basement at 200m depth, but sticky mudstone which was not encountered at another test well, lies from 152m. Static water level was very deep as 152.95m and conductivity was so high as 15,680μ S/cm.

(1) Geology

1) Cutting observation
The cutting sample indicates fine sand with not-very thick passage of coarse sand and argillaceous or calcareous until 140m. Interlay ring thin bed of clay, sand cemented with calcareous, mudstone and limestone, starts 140m to the bottom. Calcareous-sand is supposed between 25 and 45 m. and 100 and 110 m of depth. The shape of the grain is round and color is of red yellow or brown color. Remarkable characteristics of this borehole are
・Existence of sticky mudstone. The geology completely changes at 148.92m, after mudstone is encountered.
・3-5cm size of the gravel made of volcanic rock and weathered granite exist in the mudstone. The state of existence is not like a thick layer, but rather like a thin layer or appears randomly.
These characteristics hadn't been observed at any other boreholes.

2) Logging

The high resistivity structure which was interpreted by the VES, haven't been confirmed by the resistivity log. In particular, formation has low resistivity below 54m.
The formation resistivity beyond 145 m of depth is definitely very low, that is confirming the argillaceous nature of the drilling cuttings.

Depth		Resistivity	Geology	Comparison with VES,W183, Almost equal point.	
0	12	Above mud	Oxidized sand deposit	780-115	Upper sand is very loose and contains air between grains, then resistivity is high, but, consolidation starts a few meter beneath.
12	46	50-70 の thin bed interlayered	Calcareous sand, consolidated	285-150	The interlayered thin bed is not interpreted.
46	54	100	Calcareous sand, consolidated, calcareous sand decrease at the lower part	150	It is interpreted as mass high resistivity structure continuing above.
54	80	100-10, decrease gradually	Sand, consolidated	150	Structure doesn't match.
80	115	15	Calcareous sand, consolidated	150	The low resistivity structure is not interpreted.
115	125	50	Sand	150	
125	140	50-10, decrease gradually	Sand	150	
140	200	10	Mudstone and sand/sandstone interlayered	67	Complex structure nor low resistivity are not interpreted.

(2) Completion
The screen was installed intermittently from 36.55m to 196.15m where coarse sand exist or higher resistivity indication

The development was continued for approximately 53 hours. It revealed a low discharge of about 100 to 300 l/h and an increasing salinity exceeding 15 000 µS/cm at the end of the air-lift. Water was injected to the well several times because discharge was too small to clean mud. Furthermore, intermittent operation was done to recover water level to store enough water in the borehole. Water didn't change to clear although a several attempt were done, then airlift was terminated when conductivity was recovered as one before injection of water.

(3) Pumping Test
Analysis of data for step draw down test is impossible because water level lowered immediately and exceeded the pumping level. Yield was very little from formation, for example, it took 390 minutes for recovery after 30 minutes pumping at 0.96m3/h

Total pumped quantity was around 450L to500L at any rate of step drawdown test. Hydraulic coefficient was calculated at the most lowest pumping rate.

(4) Evaluation
Permeability is very low although the formation was mostly consisting of sand deposit because sand is consolidated with silt or calcium. It was revealed that no mud loss was observed through drilling above 140m. This mobility of water causes high conductivity of water.
This drilling result indicates that water movement in the sand is not homogenous, may flow at the limited passage.
Clarified characteristics are

- Water level is 50m above sea level (static water level is 153m while the Ground level is 203m ASL.), which is higher than F015 in Ambovombe
- Water does not exist or too small yield to recognize in the sand above 140m depth
- An aquifer was encountered below mudstone where moderate mud loss occurs.

- Basement does not exist up to 200m of depth while old data near to this site indicates existence of basement.
- In the mudstone, deposit of volcanic material were encountered

DP2.6.11 F 019

The objective was to confirm aquifer in the quaternary dunes in the south of Ambovombe. The targeted depth of 200 m starting from an altitude of 215 m could reach to aquifer laying over the sea level.

Screens were installed nearly at the most of parts; however, borehole was completely dry. Gradient of aquifer near the sea level might be very gentle and potential of aquifer above sea level at the coastal dune might be very low.

(1) Geology
1) Cutting observation
Sand colored as red brown was found until the bottom from the surface. Borehole passes dune sands up to 203 m of depth, which is cemented with calcareous. The color of the dune sand is yellow beige.

2) Logging
The gamma ray log indicates three intervals anomaly between 10 and 20 m, around 25 m and 60 m. But, no particular counter response is observed at the resistivity log or geology
Resistivity structure resemble to the structure interpreted by VES in large scale.

Depth		Resistivity	Geology	Comparison with VES, W111, 1500m to the south west, altitude is 212m, lower about 8m. No compensation for comparison.	
0	5	Above mud	Oxidized sand deposit	182	Upper sand is very loose and contains air between grains, then resistivity is high, but, consolidation starts a few meter beneath.
5	12	40	Consolidated calcareous sand	51	Resistivity structure coincides
12	22	40-70 increase gradually	Consolidated calcareous sand	175	Resistivity structure coincides. But, bottom of this layer is interpreted as much deeper. The difference of value causes of the drilling mud which makes formation wet,
22	30	60	Sand decreasing calcium, with ilimenite	175	
30	60	60-10 decrease gradually	Consolidated calcareous sand	28	Resistivity structure coincides。
60	130	10	Sand, faint white color cause of calcium. Lower part is consisting with calcareous sand, but concentration is varying.	28-22	
130	172	10-30 increase gradually	Consolidated calcareous sand, but up part decrease concentration of cal calcium	22	Resistivity structure coincides, but thin layers not separated.
172	186	30-60ecrease gradually	Sand, oxidized color	22	
186	200	60-40decrease	Sand	22	

(2) Completion
The casing bottom was supposed to be installed at 200m. But the borehole collapsed at 22 m depth after the operation of logging and was buried until certain depth. Thus, the casing depth was modified to 178 m.
The screen was installed at 82.5 and 104.9 m, 119.0 and 135.85 m, 155.5 and 175.2 m. and 59 m.

The development was executed intermittently with about 10 minutes interval with halting during about 6 hours because water nearly dried up immediately after start of air-lift. Water of 6 m^3 drawn at F015 was poured (Pouring was done in 6 times. each quantity was about 2 m^3) into the hole. The airlift was done, but hole was dried up within 5 to 10 min.

(3) Pumping Test
It was not executed because of no water.

(4) Evaluation
F019 was drilled through calcareous-sand composed with dune sand which was fairly consolidated. So that, it was difficult to prevent collapsing once it stars collapse during drilling. Collapses caused the stop of drilling and then need to drill again at different point for three times. The third point is approximately 300 m away from the first point at an altitude of 215 m (according to GPS), 8 m lower than the first point.
The casing bottom is approximately at +37m above sea level . It is clear that static water level is below this altitude.

Gradient of aquifer between F015 and the sea is +11 m (GPS)/9.500 m = 1.15m per thousand meters, while there is 2 km distance between F015 and F019 of North-South. The water level should be + 8.7 m = 11 m – (2 000 m X 1.15 m per thousand =2 .3m) of altitude. It can say that aquifer at F019 lay 28 m deeper from the drilling depth. The 200 m depth was probably insufficient to reach to aquifer, even if collapse didn't occur.

DP2.6.12 F022

Objective of the F022 is to identify aquifer above sea level at which altitude is less than 100m, to clarify capability to install manual pump. There were several pumping systems and it had functioned for several years at this area at 1980's.

The sufficient yield of aquifer for manual pump was confirmed, but conductivity is so high as 10,000µS/cm. But village people are pleased to use this water because other water source is not available around this area. The manual pump was installed to verify effectiveness of water.

(1) Geology

1) Cutting observation
Calcareous sand and sand interlay with 15-30m interval. The penetration speed slows down at calcareous sand, so that, it might be well consolidated or cemented like rock. The penetration slows down to moderate speed at some other part, those part is also includes certain calcium which bond sand grains.

2) Logging

The resistivity deeper than 60m (static water level) show higher resistivity. If permeability of formation is high enough, the log shall show low resistivity because groundwater has high conductivity. This indicates aquifer is not distributed in the sand formation.

<table>
<tr><th colspan="2">Depth</th><th>Resistivity</th><th>Geology</th><th colspan="2">Comparison with VES, W014, 235m to the north west, altitude is 115m, higher about 35m. No compensation for comparison.</th></tr>
<tr><td>0</td><td>2</td><td>Above mud</td><td>Calcareous sand, cemented</td><td>155</td><td>Cemented calcareous sand exist and show higher resistivity</td></tr>
<tr><td>2</td><td>15</td><td>100-30 decrease</td><td>Calcareous sand, cemented</td><td>40-135</td><td>Cemented calcareous sand exist and show higher resistivity`. 40ohm-m might be due to noise or analysis error</td></tr>
<tr><td>15</td><td>45</td><td>35</td><td>Sand, lower part is calcareous sand</td><td>28</td><td>Resistivity structure coincides with log.</td></tr>
<tr><td>45</td><td>75</td><td>25</td><td>Upper part is calcareous sand, lower part is sand</td><td>7</td><td rowspan="4">Actual absolute value is not low as interpreted value, but structure of resistivity matches. Different four layers are observed, but are not distinguished due to faint contrast.</td></tr>
<tr><td>75</td><td>90</td><td>25-45increase</td><td>sand</td><td>7</td></tr>
<tr><td>90</td><td>110</td><td>45</td><td>Calcareous sand</td><td>7</td></tr>
<tr><td>110</td><td>120</td><td>45-15 decrease</td><td>Consolidated sand</td><td>7</td></tr>
</table>

(2) Completion

Casing screen was installed at which resistivity logs show higher value because the position of aquifer was not well clarified.

The development was executed continuously for 8 hours with 2-3m3/h. Static level changed from 42.2 at the start to 60 m at the end. According to the change of natural static water level, the yield had decreased gradually. This gradual change reflects small quantity of yield, but just enough quantity for cleaning borehole.

(3) Pump test

a. Potential of borehole is low because the drawdown of each step still continued to drop.
b. Borehole is not well cleaned because the specific yield had improved as the test continued.
c. The water quality improved as test continued from 8820µS/cm to 5760µS/cm. Water quality of groundwater which migrate form not near by borehole might have smaller conductivity.

(4) Evaluation

The aquifer was confirmed, but conductivity exceeds preferable value for drinking usage and cooking for cassava which is principle food for village people. However, despite these negative characteristics, this water gave positive impact to the village people.

Sand dune tends to be sought as homogenous permeable formation, but the permeable part is maldistributed. This was supported from the absence of mud loss during drilling.

The conductivity of water changed lower in the process of pumping. But, the conductivity returns to high after installing pump. Now water consumption is about a few m3 per day. This indicates permeable water is lower conductivity than stagnant water in place.

Remarkable characteristics are

- Static water level is +18m above sea level.
- Hard rock does not exist up to 120m depth, while there is outcrop at the north western part of region.

DP2.6.13 F 030

The F030 was executed at the village of Ekonka which is 10 km away to the south of Ambovombe. The initial objective was to confirm aquifer in the quaternary dunes in the south of Ambovombe. The targeted depth was 200 m starting from an altitude of 180 m which could reach to aquifer laying over the sea level.

The aquifer existed, but yield was too little to notice during development. It was noticed by monthly monitoring of static water level as its water level had increased to 175 from 181.4m.

(1) Geology

1) Cutting observation
The cutting showed calcareous sand/sandstone composed of dune coarse sands colored beige up to 205 m of depth. Slightly brown russet-red clay passages are noted in the depth from 4m to 8m, and 21m to 25m. Several passages contain black elements which might be ilmenite.

2) Logging
The probe of gamma ray did not function well. The resistivity log indicate passages more resistive formation. Formation resistivity relatively high although sand is cemented with lime while resistivity drops below static water level.

Depth		Resistivity	Geology	Comparison with VES, W009, 158m to the south, altitude is 158m, lower about 18m. No compensation for comparison.	
0	6	above mud	Strongly weathered sand and particle of lime	175-130	Sand is loose and contains air between grains, and then resistivity is high. The difference might cause of mud invasion to the formation.
6	12	70-120 increase	Fairly weathered sand and particle of lime	500	High resistivity is conducted by relationship of other layers. This caused of a error of analysis.
12	16	120	Sand and particle of lime	500	
16	30	70	Sand and particle of lime	210	Value doesn't match with log, but structure reflects actual state.
30	98	80	Calcareous sand	210-98	
98	104	130	Calcareous sand	98	
104	144	60	Calcareous sand	98	
144	148	80	Calcareous sand	98	
148	168	60	Sand	11	Depth doesn't match with log, but structure reflects actual state.
168	172	80	Sand	11	
172	200	10	Calcareous sand	11	

(2) Completion
The screen was installed in most of the casing expecting aquifer in the sand and limestone. The hole repeatedly collapsed and buried 16m above the targeted bottom of 200m although effort of cleaning with several hours before installation. Eventually, the bottom of the casing was modified.

The development was executed intermittently with about 15minutes interval with halting 30 minutes during about 8 hours because water nearly dried up immediately after start of air-lift. Water of 8m^3 drawn at F015 was poured (Pouring was done in 4 times. each quantity was about 2 m^3) into the hole. The airlift was done, but hole was dried up within 5 to 10 min.
The measured water level is 173.8 m of depth on January 4 (2 days later the end of the development) and 174.95 m on January 6 (4 days later the end of the development).

(3) Pumping Test
The submersible pump was installed at 182 m of depth, which was one meter above bottom and 7m below the water level. The borehole was dried up immediately after pumping started. It was impossible to continue the test.

(4) Evaluation
It was not clear whether the borehole was dry until monthly monitoring was done because yield was nearly

dry and conductivity was equal to the injected water to wash mud during development. It was confirmed the static water level was 177.55m which was higher than bottom of screen and conductivity was 7000 μS/cm.

Clarified characteristics are

- No effective perched water in the dune
- Water level exists above sea level, but very small yield and high conductivity.

DP2.6.14 F 032

The objective was to identify the depth of the basement and its aquifer potential at the relief of Ambovombe. It can be proved that possibility of gravity feed system at relatively short distance to urban (11 km) in case that water resources was confirmed.
Neither basement nor aquifer was confirmed until 205m depth. Since the altitude is 229m, then water level is below 24m.

(1) Geology

1) Cutting observation
The cuttings show weathered calcareous sand/sandstone composed of fine, medium grain, mostly cemented with calcareous (all the samples react to the acid chloride). Certain passages of the layer composed with an argillaceous or ferric red may reflects of degree of oxidization or interruption of sedimentation. These depths are 91m, 97m, 123m, 158m, 168m, 185m, 192m.

2) Logging
The data of the VES show high resistivity layer above low resistivity structure. But, apparent contrast of geology or characteristic wasn't confirmed.
Although the change of the color showed degree of oxidization and consolidation, the log didn't show any difference from the upper and the lower layers.

Depth		Resistivity	Geology	Comparison with VES, W049, 3700m to the east, altitude is 247m, higher about 20m. No compensation for comparison.	
0	10	above mud	Oxidize calcareous sand	185-133	Oxidized and not consolidated
10	50	Fluctuation 70-100	Oxidize calcareous sand	67	No clear reason of this response
50	70	Decrease 80-40	calcareous sand, decreasing calcium at lower part	132	Value is different from log resistivity. This might cause of invasion of mud
70	116	40	calcareous sand	132	Lower resistivity formation under higher resistivity. This match with actual structure
116	130	30	calcareous sand	132	
130	170	Increase 40-80	calcareous sand	15	Structure doesn't match with actual, this might cause of bad condition near surface for survey.
170	180	70	calcareous sand	15	
180	200	100	calcareous sand	15	

(2) Completion
The screens were positioned to target the deep aquifer or coarser sand passages

The development was executed intermittently with about 15minutes interval with halting 15 to 30 minutes during about 11 hours because water nearly dried up immediately after start of air-lift. Water of 6m^3 drawn at F015 was poured (Pouring was done in 4 times. each quantity was about 2 m^3) into the hole.
The measured water level was 191.77m of depth on January 22, that was equal to the bottom of screen.

(3) Pumping Test
It was not executed because no water existed.

(4) Evaluation
The site was sought as potential area of groundwater because the resistivity interpreted by VES is obviously higher although most of sites were low resistivity structure. As result of drilling, it was found that it was calcareous sand/sandstone.
Remarkable characteristic are

- Effective perched aquifer does not exist
- The drilling can't reach to the basement. Water level is beneath +22m altitude = 227m -205m although metamorphic rock is outcropped at the top of watershed between Ambovombe and Ambossary.
- Sediments continue until 205 m at least.

DP2.6.15 SE1

Objective is to evaluate potential of shallow aquifer near main vovo area of Bevory.
The well was drilled up to 44m and completely dry because no impermeable formation retaining water didn't exist.

(1) Geology
1) Cutting observation
Weathers oxidized formation continue to 16m, and then calcareous sand continue to the 44m.

2) Logging
General structure matches between resistivity log and VES. Resistivity log express thin layers.

Depth		Resistivity	Geology	Comparison with VES, W130, 650m to the south west, altitude is 144m, almost equal. No compensation for comparison.	
0	3	above mud	Oxidized calcareous sand	332	Oxidized and not consolidated
3	8	120	Oxidized calcareous sand	172	Oxidized and not consolidated
8	9	80	Oxidized calcareous sand	172	
9	14	120	Oxidized calcareous sand	172	
14	20	20	calcareous sand	172	
20	26	40	calcareous sand	12	Formation might be wet but not saturated. The resistivity might much higher if it is wet.
26	29	120	calcareous sand	12	
29	36	20	calcareous sand	12	
36	44	100	calcareous sand	12	

(2) Completion
Casing was not installed because borehole could not retain mud and it was concluded dry formation.

(3) Pumping Test
It was not executed because no water existed.

(4) Evaluation
The formation beneath of the perched layer is permeable and then, the perched aquifer continues to very thin layer and to the limited depth.

DP2.6.16 SE2
This borehole was drilled just near SE1. Considering the result of SE1, it was concluded that the depth

exceeds bottom of aquifer, then the drilling depth was stopped at 24m. But, no water was encountered. From this result, any aquifer doesn’t exist in this area although place is located the rim of main vovo area. The formation beneath of the perched layer is permeable and then, the perched aquifer continues to very thin layer and to the limited depth.

DP2.6.17 SW1

Objective is to evaluate potential of shallow aquifer near major vovo area of Mitsangana.
The well was drilled up to 33m until reaching clay. Groundwater was confirmed.

(1) Geology
1) Cutting observation
Weathered oxidized formation continues to 12m, and then is followed by sand with clay formation. Green clay is sought as the bottom of aquifer in general.

2) Logging
General structure matches between resistivity log and VES. VES worked to detect clay formation, but value of log change gradually compared with the actual geology.

Depth		Resistivity	Geology	Comparison with VES, W135, 130m to the south east, altitude is 138m, almost equal. No compensation for comparison.	
0	5	above mud	Oxidized calcareous sand	135	Oxidized and not consolidated
5	15	70-50	Oxidized calcareous sand	40	Lower resistivity structure than upper formation
15	30	30-20	Sand including little xaly	40-5	
30	33	20	Green clay	5	Very low resistivity formation

(5) Completion
Casing was installed targeting formation above clay and bottom oxidized sand.

The development was executed intermittently with about 20-50minutes interval with halting 10 to30 minutes during about 9 hours because water nearly dried up immediately after start of air-lift. Water of $8m^3$ drawn from F015 was poured (Pouring was done in 4 times. each quantity was about 2 m^3) into the hole. Conductivity of water increased as well was developed.

(6) Pumping Test
Water column was not enough for keep pumping even at 3.17L/min. So that, step drawdown test was not effective. Data of the first step was used to calculate hydraulic coefficient. Eventually, conductivity increased up until 7020μS/cm.

(7) Evaluation
Combination of impermeable green clay layer and little groundwater were confirmed. The clay layer is a condition of existence of groundwater at Ambovombe, especially, southern area. The extension and figure of layer might determine capacity of shallow aquifer.
If the structure is simple, VES can interpret depth of clay formation.

DP2.6.18 SW2

Objective is to evaluate potential of shallow aquifer near major vovo area of Ambaro.
The well was drilled up to 24m until reaching clay. Groundwater was confirmed.

(1) Geology

1) Cutting observation

Weathered oxidized formation continues to 11m, and then is followed by sand with green clay formation. Green clay is sought as the bottom of aquifer in general.

2) Logging

Log data is not well acquired because mud level was too low for equipment. VES works to detect clay formation..

Depth		Resistivity	Geology	Comparison with VES, W137, 137m to the east, altitude is 140m, almost equal. No compensation for comparison.	
0	17	above mud	Oxidized sand	120-40-6	Lower resistivity structure than upper formation
17	24	?	Sand including green clay	6	Very low resistivity formation

(5) Completion

Casing was installed targeting formation above clay and bottom oxidized sand.

The development was executed intermittently with about 20-25minutes interval with halting 20 to30 minutes during about 6 hours because water nearly dried up immediately after start of air-lift. Water of 7m^3 was poured (Pouring was done in 7 times. each quantity was about 1 m^3) into the hole.

(6) Pumping Test

It was not executed because water column was not enough for pumping.

(7) Evaluation

Combination of impermeable green clay layer and little ground water was confirmed. The clay layer is a condition of existence of groundwater at Ambovombe, especially, southern area. The extension and figure of layer might determine capacity of shallow aquifer.

DP2.6.19 NW

Objective is to evaluate potential of shallow aquifer near major vovo area of Beabo.
The well was drilled up to 19m until reaching clay. Groundwater was confirmed.

(1) Geology

1) Cutting observation

Weathered oxidized formation continues to 9m, and then is followed by sand with clay formation. Calcareous sand does not exist at near surface. This is different from southern part.

2) Logging

Log data is not well acquired because mud level was too low for equipment. VES works to detect clay formation..

Depth		Resistivity	Geology	Comparison with VES, W147, 250m to the south east, altitude is 131m, almost equal. No compensation for comparison.	
0	?	above mud	Oxidized sand upto 9m	116-48	Oxidized and not consolidated
?	?	?	Sand including little clay 19m まで	6	Lower resistivity structure than upper formation

(1) Completion

Casing screen was installed targeting formation above clay and bottom oxidized sand.

The development was executed intermittently with about 20-30minutes interval with halting 10 to 20 minutes during about 5 hours because water nearly dried up immediately after start of air-lift. Water of 14m^3 was poured (Pouring was done in 7 times. each quantity was about 2 m^3) into the hole. Conductivity of water didn't change throughout of development.

(2) Pumping Test
It was not executed because water column was not enough for pumping.

(3) Evaluation
Combination of impermeable green clay layer and little ground water were confirmed. But color of the clay layer is grey than green of southern area.

DP2.6.20 FP010

Objective is to evaluate potential of shallow aquifer near P010 to confirm existence of water.
The well was drilled up to 31m, but neither particular clay layer nor groundwater existed. According to this result, it was concluded that P010 was dry and pump is installed old well after its rehabilitation.

(1) Geology
1) Cutting observation
Weathered oxidized formation continues to 31m,

2) Logging
Log data and VES doesn't match its resistivity structure.

Depth		Resistivity	Geology	Comparison with VES, W008, 1900m to the west, altitude is 206m, almost equal. No compensation for comparison.	
0	4	above mud	Oxidized red sand	9	Lower part was interpreted as higher resistivity.
4	18	50	Sand bright color with little clay	9	
18	31	25	Oxidized red sand	18	

(4) Completion
Casing screen was installed targeting formation above clay and bottom oxidized sand.

The development was executed intermittently with about 120minutes interval with halting 20 to 30 minutes during about 10 hours because water nearly dried up immediately after start of air-lift. Water of 14m^3 was poured (Pouring was done in 7 times. each quantity was about 2 m^3) into the hole. Conductivity of water didn't change throughout of development.

(5) Pumping Test
It was not executed because water column was not enough for pumping.

(6) Evaluation
Considering shallow well and seasonal pond beside of this point, existence of aquifer was expected. Absence of impermeable layer caused of absence of shallow ground water. This indicates perched aquifer is discontinuous and rainwater can percolate at the gap of aquifer.

DP2.6.21 P 003

The objective was to recognize qualities of the aquifer perched in the Neocene Continental in the east of

Ambaliandro at the central part of the basin. The continuation of recharge from upstream of basin can be proved if shallow aquifer exists.

The groundwater was confirmed, but, it was very saline, thus this aquifer might not have relationship with this certain point of the continuous groundwater gradient from upstream to downstream of the basin, taking into account of static water level of the F006 and the Ambovombe.

The well was not equipped with manual pump because salinity was too high, but village people made use for their consumption because distance to the nearest water source is 8.5km away.

(1) Geology

The formation is cemented with clay, silt and calcium as like rock. The major grain is angular gravel/sand of quarts. The block of cutting is hard to break at the state of dry, but it melted immediately once it was dipped into water. This indicates primary cementing material is silt. Calcium exists at the most of formation, but as a tiny particle. Clay exists from 5 to 10m where color of formation is green, but with much of silt. Existence of calcium was check by hydrochloric acid.

Water was struck at 19.6 m in this breccias sandstone. Water is salty with a conductivity of 10,350 μ S/cm, then digging was terminated.

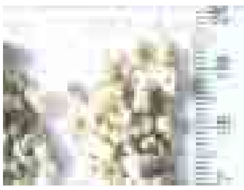
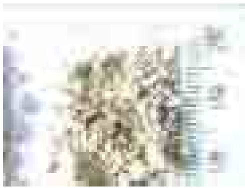
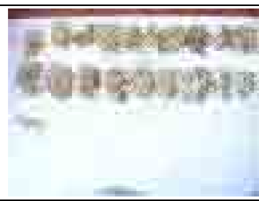
			
6m	12m	17m	All depth

Figure 2.6-1 Drilling sample of P003

(2) Pumping Test

Water column is 0.17m and yield is too small to keep pumping level at even 4L/min. Therefore, step pump test was not effective. Hydraulic coefficient was calculated with data of first step.

(3) Auxiliary test

The sampled soil was subject to an experiment of soaking them in not very mineral-bearing water ("Eau Vive" a bottled mineral water with conductivity 40μS/cm) and measuring the evolution of the conductivity of the water in time. Immediately after the mixture, the conductivity of the majority exceeds 1000μS/cm. Mineralization continues to evolve/move the following days. It is getting slightly higher.

This result might indicate contamination of certain strong salt in the soil.

Table 2.6-1 Evolution of conductivity of the soaked cutting of P 003 in the water

Depth	5 m	6 m	7 m	11 m	13 m	15 m	17 m	19 m	20.2 m	Moyenne
1 day	1,030	750	1,420	1,345	1,340	690	120	160	115	
3 day	1,440	920	1,420	1,570	1,610	910	210	320	300	
5 days	1,410	990	1,480	1,570	1,610	910	230	320	230	
15 day	1,490	1,000	1,480							
3 month	1,680	1,130	1,600	1830	1,850	1,150				

(4) Evaluation

Clarified characteristics are

- Water struck at 19.65m in sandstone composed with coarse sand and gravel of quartz elements
- Aquifer might have relationship with well in Ambaliandro(GPS ID 015) because water level and conductivity resemble.
- Formation includes certain soluble mineral which change conductivity 40 to 1.000-2000 μ S/cm.

DP2.6.22 P004

This well was constructed in the north-eastern part of the basin in order to recognize the potential of this zone and confirmation of water level at shallow depth. The inhabitants did not want to be disturbed by people coming to draw into their village, so they requested to move the point 1.5 km away from the village.

The digging progress was very slow and took more than one month for 3.7m because the formation was sandstone with gravel. It is very hard to continue to break by hand tools, and then terminated at this depth. Information is not collected at this point, but the result of F009 and F014 indicates scarce chance of existing aquifer.

(1) Geology
The 3.5 m dug in this well is reddish clayish-sandy conglomerate composed breccias gravel and coarse sand. It was very hard to dig

(2) Auxiliary test
Salinity contents in formation was tested
The same experiment as on the P 003 was executed: sampled soil were mixed with mineral water and were monitored change of conductivity during several days.
Contrary to the samples of the P 003 (whose water of the well has a conductivity of about 2,000 µS/cm). the conductivity didn't increase and keep about 200 µS/cm.

Table2.6-2 : Conductivities of sampled soil diluted in fresh water

Depth	2 m	3 m	Average
1 day	48	49	49
3 day	87	135	111
5 day	113	131	122
10 day	170	240	205
15 day	190	255	222
90day	200	300	250

(3) Evaluation
The type of formation is apparently different from coastal area neither Ambaliandro. The formation is likely to be formed by river sediments. Clarified characteristic are

- This area covers with reddish clayish-sandy conglomerate composed breccias gravel and coarse sand although this area is seemed deposit of Neogene's sand. The hardness is not proper to hand dug well.
- Salt content is not significant as coastal and ambaliandro.

DP2.6.23 Well P008

This well was constructed in the village of Betioky at which foot of the eastern hills between Ambossary. Objective is to clarify the potential at the sector of eastern Ampamoloro and the upstream of great depression at Lafidava (which extends to Ambovombe) and to the temporary lake Sarimonto. Existence of perched aquifer was expected because recharge from eastern mountains enables to recharge in the view of topography.

(1) Geology
There was hard calcareous sandstone with coarse sand grain up to 6 m. then geology turn to the coarser, not very argillaceous russet-red, weak cohesion until 25m. The well appeared always dry and without moisture to 25 m of depth.

(2) Evaluation

Having consultation of the existing documents, in particular "hydro geologic research in the basin of Ambovombe page 10 and 11 " (Henri Besairie March 1959). It proves that the sector is unfavorable to hit water, and was the subject of many unfruitful research, either for no water or for too high salinity.

Clarified characteristic are

- No perched aquifer was encountered
- Shallow depth of this area covers with reddish clayish-sandy conglomerate composed breccias gravel and coarse sand although this area is seemed as like bottom of muddy pond. If bottom of Sarimonto lake has the same structure, water is not percolate underneath in general.
- The hardness of hard layer is rather weak than P003 and was broken as small block

DP2.6.24 P009

The point was selected to verify potential as water source for a small-scale water supply to be equipped with solar system. The area is not beneficiated with major vovos because of distance, but potential was expected because the site is not so far from those areas.

Although the aquifer existed, the yield is not enough to install motor pump, then a rope pump is installed. Conductivity is better than other area as 2200µS/cm.

(1) Geology

Most of the formation is consisted with sand, and thin passage of calcareous sand at 5.5m-6.4m. Aquifer starts 19.2m in the sand formation, the digging was terminated before reaching clay formation because wall of shallow well tends to collapse.

(2) Pumping Test

Water level lowered immediately until pump after pump started, so step drawdown test was not effective. The static water level was 19.31m and maximum pumping level was 19.54m. Water column was just 23cm. Pumping time was 20 minutes at 6L/min, but 110minutes to recover. Well capacity of yield was very weak.

(3) Evaluation

The water is acceptable for drinking at Ambovombe because electric conductivity is 2200µS/cm. However, the yield is too low to install motor-pump, so that, rope pump was selected. Because yield is not enough at Ambovombe area, it is not feasible to make planning motor pump installation exploiting groundwater of the perched aquifer.

DP2.6.25 P010

The point was selected to verify potential for small-scale water supply to equip pump because shallow aquifer is frequently used this area.

Any groundwater doesn't exist at this point although a functioning shallow well and seasonal big pond exists beside. Absence of aquifer might cause of absence of impermeable formation to retain water. Water level rise during heavy rain, but it returned after stop immediately.

(1) Geology

Sand formation continues from surface, white sand which is forming aquifer in general starts from 4m. This formation tended to collapse due to absence of sand.

(2) Evaluation

Aquifer is not encountered although formation is consisted with white sand. Because of struggling to keep digging, the formation was checked by air drilling. As a result of that, it was confirmed that reddish sand lay underneath of white sand and absence of water. Then, digging was terminated.

White sand distribution might be discontinuously, then, capacity of storage is limited. Rainwater might not be perched if retention formation is not exist. That might be a reason of small yield of aquifer and misdistribution of vovo at this area.

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DP2.7 Environmental and Social Consideration

Scoping

Scoping of this project is given in the table following.

Dp2.7.1 Rural Water Supply

(1) Scoping

Table DP2.7.1-1 Provisional Scoping – Rural Water Supply

Environmental Elements			Rating	Justification of Scoping
Social Environment	1	Resettlement	D	Large-scale water-supply facilities that entail resettlement is not in the scope of the plan.
	2	Regional Economy including employment and livelihood)	C	Drinking-water sellers may loose business.
	3	Land use and regional resources use	D	Small-scale water-supply facilities will be constructed. However, local villagers' consent need to be obtained during pilot drilling phase.
	4	Social capital and local decision-making institutions	C	The community has traditions and rules which need to be considered when the location of borehole is decided.
	5	Existing social infrastructure and social services	D	Existing public water supply services are not satisfactory in terms of volume and quality. The proposed project intends to improve the services.
	6	The poor, indigenous and the ethnic minorities	C	If the water source distribution is eccentrically located, it might be affected.
	7	Inequitable distribution of adverse impacts and benefits	C	Inequities in benefits distribution among stakeholders are not anticipated. However, groundwater availability is finite. Therefore, the upcoming development study shall clarify the issue of benefits distribution.
	8	Conflict of interest among the stakeholders	C	Inequities in benefits distribution among stakeholders are not anticipated. However, groundwater availability is finite. Therefore, the upcoming development study shall clarify the issue of benefits distribution.
	9	Gender	C	The proposed project essentially benefits women. However, the manner in which women participation is realized need to be elaborated in the upcoming development study.
	10	Children's Rights	D	Children, who are used to be engaged in fetching water for domestic consumption, will mostly be benefited.
	11	Historical and Cultural Monuments	D	In the targeted community, there are no designated historical and cultural heritages that will be impacted. Or, the proposed project size is so small that it will have any significant impact.
	12	Infectious Disease like HIV and AIDS	D	Project implementation will have no causal relationship with the incidence of HIV and AIDS.
	13	Water Rights	C	If the main water source is distributed in Antanimora commune, there may be conflict between the source commune and the beneficiary commune.
	14	Public Hygiene and Sanitation	D	One of the intended benefits of the proposed project is to reduce the incidences of water-borne diseases. Public hygiene and Sanitation will be improved.
	15	Solid Wastes	D	The anticipated volume of the solid wastes from drilling, excavation and construction work is very marginal and it is within local capacity of proper treatment and disposal. (Screening has eliminated the item.)
	16	Natural Disaster (Risk)	D	Risks of drought will be reduced by implementing the proposed project.
Natural Environment	17	Topography and geology	D	The size of the proposed project will not alter local topography and geology.
	18	Soil Erosion	D	Project implementation will have no causal relationship with soil erosion.
	19	Groundwater	C	Groundwater development may induce potential subsidence of water table and groundwater quality in the vicinity, depending on the amount of water abstracted.
	20	Hydrological Regime of Rivers, Lakes and Inland Waters	D	No impact is anticipated as the surface water is not to be developed nor utilized.

Environmental Elements			Rating	Justification of Scoping
	21	Coastal and sea zone	D	The proposed project is to be implemented inland.
	22	Biota and Ecosystems	C	No protected areas in the study area, however endemic vegetation distribute in the Antanimora Region
	23	Climate	D	A large-scale structure that may affect local climate is not within the scope of project plan.
	24	Landscape	D	A large-scale structure that may intrude landscape is not within the scope of project plan.
Pollution	25	Air Pollution	D	Anticipated amount of pollutant emissions during construction is minimal. When the water-supply facility is used for service, air pollutant emissions are negligible.
	26	Water Pollution	C	Precautions needed when drilling.
	27	Soil Contamination	D	Risk of soil contamination from discharged domestic waste water will be minimal.
	28	Noise and Vibration	D	The levels of noise and vibration generated from water-supply facilities are to be controlled by construction supervision and on-site management of facilities operation.
	29	Land Subsidence	D	The water abstraction rate is substantially low, so that chances of land subsidence is very low.
	30	Bad Odor	D	No sources of bad order are anticipated.

reference: "Environmental Guidelines for Infrastructure Projects", JICA, 1992 (some modifications)

Note : Evaluation classification

A : Expected serious impact
B : Expected somewhat impact
C : Not clear
D : IEE or EIA is not necessary (no expected impact)

(3) Envisioned Mitigation Measures / Items to be considered

TableDP2.7.1-2 Envisioned Mitigation Measures - Rural Water Supply

Item		Rating	Mitigation Measures / Items to be considered
2	Regional Economy including employment and livelihood)	C	To conduct a field survey on water-sellers and assess the number of potential job losers due to improved water-supply situation in the target communes. A plan to save those people need be formulated, which include a plan to place them as monitors at community water-supply sites.
4	Social capital and local decision-making institutions	C	A social survey to be conducted in the study area to find out the cultural and traditional understandings. Care shall be taken when deciding the location of wells.
7	Inequitable distribution of adverse impacts and benefits	C	A social survey to be conducted during the Development Study shall indicate whether inequitable distribution of adverse impacts and benefits will potentially be incurred due to the implementation of the Rural Water Supply project. Moreover, the reasons that not all residents are benefited equitably, due to the Nature's predicament, will be briefed to the Government of Madagascar as a reminder in project implementation.
8	Conflict of interest among the stakeholders	C	Assess the groundwater resources potential. Coordination and conflict resolution incurred by well-boring plan rests with the jurisdiction of the Government of the Madagascar. As such, the issue shall constitute a subject of recommendation to the Government of Madagascar.
9	Gender	C	Rural Water Supply project essentially benefits women, However, measures to extend women' participation shall be explored in the proposed Development Study.
13	Water Rights	C	Communication with the Antanimora Commune.
19	Groundwater	C	A threshold volume of groundwater to be developed sustainable shall be determined through the groundwater survey.
22	Biota and Ecosystems	C	Flora and Fauna distribution will be surveyed bibliographically. Care shall be taken in places where important species are distributed.

(3) Alternatives

Without the project, rural people will depend on scarce water sources available – surface water and groundwater. They continue to be affected by difficulty to access safe water throughout the year. In particular, in dry seasons, they will have to purchase very expensive water from water-sellers.

Alternatives: Enhancing the capacity of the existing water supply systems will be considered as an alternative plan. Following methods will be considered.

- to improve the operation of existing water treatment plant and purchase a lot of water wagons and convey the treated water (more investment and higher O&M cost are estimated)
- to build the pipeline and convey the river water after treatment (technically challenging and higher O&M cost are required

DP2.7.2 Provincial Town Water Supply

(1) Scoping

Table DP2.7.2-1 Scoping – Provincial Town Water Supply

Environmental Elements			Rating	Justification of Scoping
Social Environment	1	Resettlement	D	Large-scale water-supply facilities that entail resettlement is not in the scope of the plan.
	2	Regional Economy including employment and livelihood	C	Drinking-water sellers may loose business.
	3	Land use and regional resources use	D	Small-scale water-supply facilities will be constructed. However, local villagers' consent need to be obtained during pilot drilling phase.
	4	Social capital and local decision-making institutions	D	Social capital will be maintained, notwithstanding replacement of existing water supply system to the area.
	5	Existing social infrastructure and social services	D	Existing public water supply services are not satisfactory in terms of volume and quality. The proposed project intends to improve the services.
	6	The poor, indigenous and the ethnic minorities	D	The project targets the poor as beneficiaries of the proposed project. No conflicts with the indigenous and the ethnic minorities are reported.
	7	Inequitable distribution of adverse impacts and benefits	D	Inequities perceived by the poor, who do not own private wells nor oxen-driven cart, will be reduced.
	8	Conflict of interest among the stakeholders	D	The urban population of Ambovombe will generally be benefited.
	9	Gender	D	The proposed project essentially benefits women. .
	10	Children's Rights	D	Project implementation will have no causal relationship with the children' rights. Children will indirectly be benefited.
	11	Historical and Cultural Monuments	D	In the target communes, there are no designated historical and cultural heritages that will be impacted.
	12	Infectious Diseases like HIV and AIDS	D	Project implementation will have no causal relationship with the incidence of HIV and AIDS.
	13	Water Rights	C	Coordination with the surface-water stakeholders is necessary, if the proposed plan intends to exploit the surface water.
	14	Public Hygiene and Sanitation	D	One of the intended benefits of the proposed project is to reduce the incidences of water-borne diseases. Public hygiene and Sanitation will be improved.
	15	Solid Wastes	D	The anticipated volume of the solid wastes from drilling, excavation and construction work is very marginal and it is within local capacity of proper treatment and disposal.
	16	Natural Disaster (Risk)	D	Risks of drought will be reduced by implementing the proposed project.
Natu	17	Topography and geology	D	The size of the proposed project will not alter local topography and geology.

Environmental Elements			Rating	Justification of Scoping
	18	Soil Erosion	D	Project implementation will have no causal relationship with soil erosion.
	19	Groundwater	C	Groundwater development may induce potential subsidence of water table and groundwater quality in the vicinity, depending on the amount of water abstracted.
	20	Hydrological Regime of Rivers, Lakes and Inland Waters	C	Surface water development and use may alter hydrological regime of river waters.
	21	Coastal and sea zone	D	The proposed project is to be implemented inland.
	22	Biota and Ecosystems	C	No protected areas in the study area, however endemic vegetation distribute in the Antanimora Region
	23	Climate	D	A large-scale structure that may affect local climate is not within the scope of project plan.
	24	Landscape	D	A large-scale structure that may intrude landscape is not within the scope of project plan.
Pollution	25	Air Pollution	D	Anticipated amount of pollutant emissions during construction is minimal. Even when the water-supply facility is used for service, air pollutant emissions are negligible.
	26	Water Pollution	C	Precautions needed when drilling.
	27	Soil Contamination	D	Risk of soil contamination from discharged domestic waste water will be minimal. .
	28	Noise and Vibration	D	The levels of noise and vibration generated from water-supply facilities are to be controlled by construction supervision and on-site management of facilities operation. .
	29	Land Subsidence	D	The amount water abstracted will substantially be low, so that chances of land subsidence are very low.
	30	Bad Odor	D	No sources of bad order are anticipated.

reference: "Environmental Guidelines for Infrastructure Projects", JICA, 1992 (some modifications)

Note : Evaluation classification

A : Expected serious impact

B : Expected somewhat impact

C : Not clear

D : IEE or EIA is not necessary (no expected impact)

(2) Envisioned Mitigation Measures / Items to be considered

Table DP2.7.2-2 Envisioned Mitigation Measures – Provincial Town Water Supply

Item		Rating	Mitigation Measures / Items to be considered
2	Regional Economy including employment and livelihood)	C	To conduct a field survey on water-sellers and assess the number of potential job losers due to improved water-supply situation in the target communes. A plan to save those people need be formulated, which include a plan to place them as monitors at community water-supply sites.
7	Inequitable distribution of adverse impacts and benefits	C	A social survey to be conducted during the Development Study shall indicate whether inequitable distribution of adverse impacts and benefits will potentially be incurred due to the implementation of the Urban Water Supply project. Moreover, the reasons that not all residents are benefited equitably, due to the Nature's predicament, will be briefed to the Government of Madagascar as a reminder in project implementation.
8	Conflict of interest among the stakeholders	C	Assess the water resources potential. Coordination and conflict resolution incurred by water-resources development plan rests with the jurisdiction of the Government of the Madagascar. As such, the issue shall constitute a subject of recommendation to the Government of Madagascar.
9	Gender	C	Rural Water Supply project essentially benefits women, However, measures to extend women' participation shall be explored in the proposed Development Study.
13	Water Rights	C	Coordination of the water rights with the Water Resources Authority shall be undertaken whenever the surface water development and use is being planned.
19	Groundwater	C	A threshold volume of groundwater to be developed sustainable shall be

Item		Rating	Mitigation Measures / Items to be considered
			determined through the groundwater survey.
20	Hydrological Regime of Rivers, Lakes and Inland Waters	C	Consultation with relevant Water Authority on surface water use and development shall be undertaken, so that their hydrological regime shall not substantially be altered.
22	Biota and Ecosystems	C	Flora and Fauna distribution will be surveyed bibliographically. Care shall be taken in places where important species are distributed.

(3) Alternatives

Without the project: urban people will depend on scarce water sources available – surface water and groundwater. They continue to be affected by difficulty to access safe water with less salt content throughout the year.

Alternatives: Enhancing the capacity of the existing water supply systems will be considered as an alternative plan. Following methods will be considered. However, when the population in the area increase, existing water resources are not enough for human security of the population.

- to improve the operation of existing water treatment plant and purchase a lot of water wagons and convey the treated water (more investment and higher O&M cost are estimated)
- to build the pipeline and convey the river water after treatment (technically challenging and higher O&M cost are required

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PART 3 SURVEY AND ANALYSIS OF SOCIIO-ECONMIC CONDITIONS

DP3.1 Water Source Classification 1/1

ID village	Source	Stratum time	Stratum price	Evaluated quality	Classification intégr	Type	ID village	Source	Stratum time	Stratum price	Evaluated quality	Classification intégr	Type
V001	V001-1	1	B	+	1B+	AA	V101	V101-1	4	D	-	4D-	G
V001	V001-2	3	A	-	3A-	G	V101	V101-2	1	C	n.d.	1C	n.d.
V001	V001-3	4	A	+	4A+	G	V1019	V1019-1	3	E	+	3E+	G
V002	V002-1	1	B	+	1B+	AA	V1019	V1019-2	4	F	+	4F+	G
V002	V002-2	3	A	-	3A-	G	V1020	V1020-1	3	E	+	3E+	G
V002	V002-3	4	A	+	4A+	G	V1020	V1020-2	4	F	+	4F+	G
V003	V003-1	1	B	+	1B+	AA	V102	V102-1	2	C	+	2C+	M
V003	V003-2	3	A	-	3A-	G	V102	V102-2	4	D	-	4D-	G
V003	V003-3	4	n.d.	+	4+	n.d.	V1022	V1022-1	3	E	+	3E+	G
V004	V004-1	1	B	+	1B+	AA	V1022	V1022-2	2	A	n.d.	2A	n.d.
V004	V004-2	3	A	-	3A-	G	V1022	V1022-3	1	F	n.d.	1F	n.d.
V004	V004-3	4	A	+	4A+	G	V1023	V1023-1	3	E	+	3E+	G
V005	V005-1	2	C	+	2C+	M	V1024	V1024-1	3	E	+	3E+	G
V005	V005-2	3	A	-	3A-	G	V1025	V1025-1	5	E	+	5E+	G
V006	V006-1	2	C	+	2C+	M	V1025	V1025-2	5	A	+	5A+	G
V006	V006-2	3	A	-	3A-	G	V1026	V1026-1	5	E	+	5E+	G
V007	V007-1	2	C	+	2C+	M	V1026	V1026-2	5	A	+	5A+	G
V007	V007-2	3	A	-	3A-	G	V1027	V1027-1	5	E	+	5E+	G
V008	V008-1	2	C	+	2C+	M	V1027	V1027-2	5	A	+	5A+	G
V008	V008-2	3	A	-	3A-	G	V1028	V1028-1	4	E	+	4E+	G
V009	V009-1	2	C	+	2C+	M	V1028	V1028-2	5	A	+	5A+	G
V009	V009-2	3	A	-	3A-	G	V1029	V1029-1	5	E	+	5E+	G
V010	V010-1	2	C	+	2C+	M	V1029	V1029-2	5	A	n.d.	5A	n.d.
V010	V010-2	3	A	-	3A-	G	V1030	V1030-1	5	E	+	5E+	G
V011	V011-1	1	A	+	1A+	AA	V1030	V1030-2	5	A	+	5A+	G
V012	V012-1	1	A	+	1A+	AA	V103	V103-1	4	D	-	4D-	G
V012	V012-2	1	A	+	1A+	AA	V1031	V1031-1	5	E	+	5E+	G
V013	V013-1	1	A	+	1A+	AA	V1031	V1031-2	5	A	+	5A+	G
V014	V014-1	1	A	+	1A+	AA	V103	V103-2	1	C	n.d.	1C	n.d.
V015	V015-1	1	A	+	1A+	AA	V1032	V1032-1	5	E	+	5E+	G
V016	V016-1	1	A	+	1A+	AA	V1032	V1032-2	5	A	+	5A+	G
V017	V017-1	2	A	+	2A+	A	V1033	V1033-1	4	D	+	4D+	G
V018	V018-1	2	A	+	2A+	A	V1033	V1033-2	2	E	+	2E+	G
V019	V019-1	2	A	+	2A+	A	V1034	V1034-1	4	E	+	4E+	G
V020	V020-1	2	A	+	2A+	A	V1034	V1034-2	2	F	+	2F+	G
V021	V021-1	2	A	+	2A+	A	V1035	V1035-1	4	E	+	4E+	G
V022	V022-1	2	A	+	2A+	A	V1035	V1035-2	2	C	+	2C+	M
V023	V023-1	2	A	+	2A+	A	V104	V104-1	3	E	-	3E-	GG
V024	V024-1	2	A	+	2A+	A	V105	V105-1	1	A	n.d.	1A	n.d.
V025	V025-1	2	A	+	2A+	A	V106	V106-1	1	A	n.d.	1A	n.d.
V026	V026-1	3	D	+	3D+	G	V107	V107-1	1	A	n.d.	1A	n.d.
V027	V027-1	2	D	+	2D+	M	V108	V108-1	5	E	+	5E+	G
V027	V028-1	1	D	+	1D+	A	V109	V109-1	5	A	+	5A+	G
V029	V029-1	5	E	+	5E+	G	V110	V110-1	4	A	+	4A+	G
V030	V030-1	5	E	+	5E+	G	V110	V110-2	5	D	+	5D+	G
V031	V031-1	5	E	+	5E+	G	V110	V110-3	5	E	+	5E+	G
V032	V032-1	5	D	+	5D+	G	V1103	V1103-1	1	C	+	1C+	A
V033	V033-1	5	D	+	5D+	G	V1104	V1104-1	1	C	+	1C+	A
V034	V034-1	5	E	+	5E+	G	V1105	V1105-1	1	C	+	1C+	A
V035	V035-1	5	E	+	5E+	G	V1107	V1107-1	1	C	+	1C+	A
V036	V036-1	5	A	+	5A+	G	V1108	V1108-1	1	C	+	1C+	A
V036	V036-2	4	D	+	4D+	G	V1109	V1109-1	1	B	+	1B+	AA
V037	V037-1	5	A	+	5A+	G	V1110	V1110-1	1	B	+	1B+	AA
V037	V037-2	4	D	+	4D+	G	V111	V111-1	5	E	+	5E+	G
V038	V038-1	5	A	+	5A+	G	V1111	V1111-1	1	B	+	1B+	AA
V038	V038-2	5	D	+	5D+	G	V111	V111-2	5	D	-	5D-	G
V039	V039-1	1	D	+	1D+	A	V111	V111-3	5	D	+	5D+	G
V040	V040-1	2	D	+	2D+	M	V1113	V1113-1	2	B	+	2B+	A
V041	V041-1	1	D	+	1D+	A	V1114	V1114-1	2	B	+	2B+	A
V042	V042-1	2	D	+	2D+	M	V1115	V1115-1	1	B	+	1B+	AA
V042	V042-2	4	D	+	4D+	G	V1116	V1116-1	3	C	+	3C+	G
V043	V043-1	2	D	+	2D+	M	V1117	V1117-1	2	A	+	2A+	A
V044	V044-1	2	D	+	2D+	M	V1118	V1118-1	2	A	+	2A+	A
V045	V045-2	2	D	+	2D+	M	V1118	V1118-2	1	A	n.d.	1A	n.d.
V046	V046-1	2	D	+	2D+	M	V1119	V1119-1	2	A	+	2A+	A
V047	V047-1	2	D	+	2D+	M	V1120	V1120-1	3	A	+	3A+	G
V048	V048-1	2	D	+	2D+	M	V112	V112-1	3	A	+	3A+	G
V049	V049-1	4	D	+	4D+	G	V1121	V1121-1	3	D	-	3D-	G
V050	V050-1	4	D	+	4D+	G	V1121	V1121-2	3	D	-	3D-	G
V051	V051-1	4	E	+	4E+	G	V112	V112-2	5	E	-	5E-	GG
V052	V052-1	4	D	+	4D+	G	V1122	V1122-1	2	D	-	2D-	G
V053	V053-1	5	D	+	5D+	G	V112	V112-3	5	D	+	5D+	G
V054	V054-1	4	D	+	4D+	G	V1123	V1123-1	3	D	+	3D+	G
V055	V055-1	4	D	+	4D+	G	V1123	V1123-2	3	D	-	3D-	G
V056	V056-1	4	D	+	4D+	G	V1124	V1124-1	3	D	-	3D-	G
V057	V057-1	4	D	+	4D+	G	V1124	V1124-2	4	D	-	4D-	G
V1125	V1125-1	3	D	-	3D-	G	V1193	V1193-1	4	E	+	4E+	G
V1125	V1125-2	3	D	-	3D-	G	V1194	V1194-1	4	E	+	4E+	G
V1126	V1126-1	2	A	+	2A+	A	V1194	V1194-2	5	B	+	5B+	G
V1127	V1127-1	2	A	+	2A+	A	V1195	V1195-1	4	D	+	4D+	G
V1128	V1128-1	4	C	-	4C-	G	V1195	V1195-2	1	C	+	1C+	A
V1128	V1128-2	1	A	+	1A+	AA	V1195	V1195-3	5	E	+	5E+	G
V1129	V1129-1	4	C	-	4C-	G	V1195	V1195-4	1	E	+	1E+	G
V1129	V1129-2	1	A	+	1A+	AA	V1196	V1196-03	5	E	+	5E+	G
V1130	V1130-1	4	C	-	4C-	G	V1196	V1196-04	1	E	+	1E+	G
V1130	V1130-2	1	A	-	1A-	G	V1196	V1196-1	4	D	+	4D+	G
V113	V113-1	4	D	+	4D+	G	V1196	V1196-2	2	C	+	2C+	M
V1131	V1131-1	1	A	+	1A+	AA	V120	V120-1	4	A	-	4A-	G
V1131	V1131-2	4	A	-	4A-	G	V120	V120-2	5	E	+	5E+	G
V113	V113-2	5	E	-	5E-	GG	V120	V120-3	5	E	-	5E-	GG
V113	V113-3	5	E	+	5E+	G	V1204	V1204-01	4	E	+	4E+	G
V1133	V1133-1	1	A	+	1A+	AA	V1204	V1204-02	1	C	+	1C+	A
V1134	V1134-1	1	A	+	1A+	AA	V1204	V1204-03	1	E	+	1E+	G

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ID village	Source	Stratum time	Stratum price	Evaluated quality	Classifica-tion intégr	Type		ID village	Source	Stratum time	Stratum price	Evaluated quality	Classifica-tion intégr	Type
V1135	V1135-1	3	A	+	3A+	G		V1205	V1205-01	4	E	+	4E+	G
V1136	V1136-1	1	A	+	1A+	AA		V1205	V1205-02	1	C	+	1C+	A
V1137	V1137-1	1	A	+	1A+	AA		V1205	V1205-03	1	E	+	1E+	G
V1138	V1138-1	1	A	+	1A+	AA		V1206	V1206-01	4	E	+	4E+	G
V1139	V1139-1	1	A	+	1A+	AA		V1206	V1206-02	2	C	+	2C+	M
V1140	V1140-1	1	A	+	1A+	AA		V1206	V1206-03	1	E	+	1E+	G
V114	V114-1	5	E	+	5E+	G		V121	V121-1	4	E	-	4E-	GG
V1141	V1141-1	1	A	+	1A+	AA		V121	V121-2	2	C	+	2C+	M
V1142	V1142-1	2	A	+	2A+	A		V122	V122-1	3	E	-	3E-	GG
V1143	V1143-1	2	A	+	2A+	A		V122	V122-2	3	C	+	3C+	G
V1143	V1143-2	3	A	+	3A+	G		V1230	V1230-1	4	E	+	4E+	G
V1143	V1143-3	5	C	+	5C+	G		V1230	V1230-2	5	A	+	5A+	G
V1145	V1145-1	3	A	+	3A+	G		V123	V123-1	3	D	-	3D-	G
V1146	V1146-1	2	A	+	2A+	A		V1231	V1231-1	4	F	+	4F+	G
V1147	V1147-1	2	A	+	2A+	A		V1231	V1231-2	5	A	+	5A+	G
V1148	V1148-1	2	A	+	2A+	A		V1232	V1232-1	3	A	+	3A+	G
V1150	V1150-1	1	A	+	1A+	AA		V1232	V1232-2	5	A	+	5A+	G
V1150	V1150-2	5	A	+	5A+	G		V1236	V1236-1	4	F	+	4F+	G
V115	V115-1	5	E	+	5E+	G		V1236	V1236-2	5	A	+	5A+	G
V1151	V1151-1	1	A	+	1A+	AA		V124	V124-1	4	D	-	4D-	G
V1152	V1152-1	2	A	+	2A+	A		V124	V124-2	2	C	+	2C+	M
V1153	V1153-1	2	A	+	2A+	A		V1249	V1249-1	3	C	+	3C+	G
V1154	V1154-1	5	A	+	5A+	G		V1250	V1250-1	3	E	+	3E+	G
V1155	V1155-1	4	A	+	4A+	G		V125	V125-1	3	D	-	3D-	G
V1156	V1156-1	4	A	+	4A+	G		V1251	V1251-1	4	E	+	4E+	G
V1157	V1157-1	5	A	+	5A+	G		V1251	V1251-2	4	A	+	4A+	G
V1158	V1158-1	5	A	+	5A+	G		V1252	V1252-1	4	E	+	4E+	G
V1159	V1159-1	4	A	+	4A+	G		V1253	V1253-1	4	E	+	4E+	G
V1160	V1160-1	4	A	+	4A+	G		V1254	V1254-1	4	E	+	4E+	G
V116	V116-1	5	E	+	5E+	G		V1255	V1255-1	4	E	+	4E+	G
V1162	V1162-1	4	A	+	4A+	G		V1256	V1256-1	4	E	+	4E+	G
V1163	V1163-1	4	A	+	4A+	G		V1257	V1257-1	4	E	+	4E+	G
V1161	V1164-1	5	A	+	5A+	G		V1258	V1258-1	4	A	-	4A-	G
V1165	V1165-1	4	A	+	4A+	G		V1258	V1258-2	4	D	+	4D+	G
V1166	V1166-1	4	A	+	4A+	G		V1259	V1259-1	4	E	+	4E+	G
V1167	V1167-1	4	A	+	4A+	G		V1260	V1260-1	4	E	+	4E+	G
V1168	V1168-1	2	A	+	2A+	A		V126	V126-1	3	D	-	3D-	G
V1169	V1169-1	2	A	+	2A+	A		V1261	V1261-1	4	E	+	4E+	G
V1170	V1170-1	2	A	+	2A+	A		V1262	V1262-1	4	D	+	4D+	G
V117	V117-1	5	E	+	5E+	G		V1263	V1263-1	1	n.d.	+	1+	n.d.
V1171	V1171-1	1	A	+	1A+	AA		V1264	V1264-1	2	n.d.	+	2+	n.d.
V1172	V1172-2	1	A	+	1A+	AA		V1265	V1265-1	2	n.d.	+	2+	n.d.
V1173	V1173-1	1	A	+	1A+	AA		V1266	V1266-1	2	n.d.	+	2+	n.d.
V1174	V1174-1	2	A	+	2A+	A		V1267	V1267-1	2	n.d.	+	2+	n.d.
V1175	V1175-1	2	A	+	2A+	A		V1268	V1268-1	1	n.d.	+	1+	n.d.
V1176	V1176-1	2	A	+	2A+	A		V1269	V1269-1	1	A	+	1A+	AA
V1177	V1177-1	1	A	+	1A+	AA		V1270	V1270-1	4	E	+	4E+	G
V1178	V1178-01	5	D	+	5D+	G		V127	V127-1	3	D	-	3D-	G
V1179	V1179-01	5	A	+	5A+	G		V1271	V1271-1	4	E	+	4E+	G
V1180	V1180-01	3	E	-	3E-	GG		V1271	V1271-2	4	F	+	4F+	G
V118	V118-1	4	A	+	4A+	G		V1272	V1272-1	5	E	+	5E+	G
V1181	V1181-01	3	E	-	3E-	GG		V1272	V1272-2	2	F	+	2F+	G
V118	V118-2	5	E	-	5E-	GG		V1273	V1273-1	4	E	+	4E+	G
V1182	V1182-01	3	E	-	3E-	GG		V1274	V1274-1	4	E	+	4E+	G
V118	V118-3	5	E	+	5E+	G		V1275	V1275-1	4	E	+	4E+	G
V1183	V1183-01	3	E	-	3E-	GG		V1276	V1276-1	4	E	+	4E+	G
V119	V119-1	4	A	+	4A+	G		V1277	V1277-1	4	E	+	4E+	G
V119	V119-2	5	E	-	5E-	GG		V1278	V1278-1	4	E	+	4E+	G
V119	V119-3	5	E	+	5E+	G		V1278	V1278-2	4	D	+	4D+	G
V1279	V1279-1	4	E	+	4E+	G		V1314	V1314-1	1	A	-	1A-	G
V1279	V1279-2	4	D	+	4D+	G		V1314	V1314-2	2	A	-	2A-	G
V1280	V1280-1	4	E	+	4E+	G		V1315	V1315-1	1	A	-	1A-	G
V1280	V1280-2	4	D	+	4D+	G		V1315	V1315-2	2	A	+	2A+	A
V128	V128-1	3	D	-	3D-	G		V1316	V1316-1	2	A	+	2A+	A
V1281	V1281-1	4	E	+	4E+	G		V1317	V1317-1	2	A	-	2A-	G
V1282	V1282-1	5	D	+	5D+	G		V1318	V1318-1	2	n.d.	-	2-	n.d.
V1283	V1283-1	5	A	+	5A+	G		V1319	V1319-01	4	E	+	4E+	G
V1284	V1284-1	5	A	+	5A+	G		V1320	V1320-01	4	E	+	4E+	G
V1288	V1288-1	4	A	+	4A+	G		V132	V132-1	4	E	-	4E-	GG
V1288	V1288-2	4	D	+	4D+	G		V1321	V1321-01	4	E	+	4E+	G
V1288	V1288-3	4	A	+	4A+	G		V1322	V1322-01	4	E	+	4E+	G
V1289	V1289-1	2	A	+	2A+	A		V1328	V1328-1	3	A	-	3A-	G
V1289	V1289-2	4	E	+	4E+	G		V1329	V1329-1	1	A	+	1A+	AA
V1289	V1289-3	4	E	+	4E+	G		V1330	V1330-1	4	A	-	4A-	G
V1290	V1290-1	3	A	+	3A+	G		V1330	V1330-2	1	A	-	1A-	G
V1290	V1290-2	4	E	+	4E+	G		V133	V133-1	4	E	-	4E-	GG
V1290	V1290-3	4	E	+	4E+	G		V1331	V1331-1	3	A	+	3A+	G
V129	V129-1	3	D	-	3D-	G		V1331	V1331-2	5	A	+	5A+	G
V1291	V1291-1	1	A	+	1A+	AA		V1333	V1333-1	2	A	+	2A+	A
V1291	V1291-2	4	E	+	4E+	G		V1333	V1333-2	5	A	+	5A+	G
V1291	V1291-3	4	E	+	4E+	G		V1334	V1334-1	4	A	+	4A+	G
V1292	V1292-1	3	A	+	3A+	G		V1334	V1334-2	5	A	+	5A+	G
V1292	V1292-2	5	E	+	5E+	G		V1335	V1335-1	5	A	+	5A+	G
V1292	V1292-3	5	A	+	5A+	G		V1335	V1335-2	4	A	+	4A+	G
V1293	V1293-1	5	A	+	5A+	G		V1336	V1336-1	5	A	+	5A+	G
V1293	V1293-2	5	E	+	5E+	G		V1337	V1337-1	2	C	+	2C+	M
V1293	V1293-3	4	E	+	4E+	G		V1338	V1338-1	3	C	+	3C+	G
V1294	V1294-1	3	A	+	3A+	G		V1339	V1339-1	3	C	+	3C+	G
V1294	V1294-2	5	E	+	5E+	G		V1340	V1340-1	2	C	+	2C+	M
V1294	V1294-3	5	E	+	5E+	G		V134	V134-1	4	E	-	4E-	GG
V1295	V1295-1	3	A	+	3A+	G		V1341	V1341-1	2	A	+	2A+	A
V1295	V1295-2	5	E	-	5E-	GG		V1342	V1342-1	3	A	+	3A+	G
V1295	V1295-3	5	E	+	5E+	G		V1343	V1343-1	2	A	+	2A+	A

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ID village	Source	Stratum time	Stratum price	Evaluated quality	Classifica-tion intégr	Type	ID village	Source	Stratum time	Stratum price	Evaluated quality	Classifica-tion intégr	Type
V1296	V1296-1	2	A	+	2A+	A	V1344	V1344-1	3	A	+	3A+	G
V1296	V1296-2	5	E	+	5E+	G	V1345	V1345-1	3	A	+	3A+	G
V1296	V1296-3	5	E	+	5E+	G	V1346	V1346-1	3	A	+	3A+	G
V1297	V1297-1	2	A	+	2A+	A	V1347	V1347-1	3	A	+	3A+	G
V1297	V1297-2	5	E	+	5E+	G	V1348	V1348-1	2	A	+	2A+	A
V1297	V1297-3	5	E	+	5E+	G	V1349	V1349-1	2	A	+	2A+	A
V1298	V1298-1	3	A	+	3A+	G	V1350	V1350-1	1	C	+	1C+	A
V1298	V1298-2	5	E	+	5E+	G	V1350	V1350-2	4	E	+	4E+	G
V1298	V1298-3	5	E	+	5E+	G	V1350	V1350-3	5	F	+	5F+	G
V1299	V1299-1	3	A	+	3A+	G	V135	V135-1	4	D	-	4D-	G
V1299	V1299-2	5	E	+	5E+	G	V1351	V1351-1	1	C	+	1C+	A
V1299	V1299-3	5	E	+	5E+	G	V1351	V1351-2	4	E	+	4E+	G
V1300	V1300-1	5	E	+	5E+	G	V1351	V1351-3	5	F	+	5F+	G
V1300	V1300-2	5	E	+	5E+	G	V1352	V1352-1	1	C	+	1C+	A
V1300	V1300-3	3	A	+	3A+	G	V1352	V1352-2	4	E	+	4E+	G
V130	V130-1	3	E	-	3E-	GG	V1352	V1352-3	5	F	+	5F+	G
V1301	V1301-1	3	A	+	3A+	G	V1353	V1353-1	1	C	+	1C+	A
V1301	V1301-2	5	E	+	5E+	G	V1353	V1353-2	4	F	+	4F+	G
V1301	V1301-3	5	E	+	5E+	G	V1353	V1353-3	1	A	+	1A+	AA
V1302	V1302-1	3	A	+	3A+	G	V1354	V1354-1	3	C	+	3C+	G
V1302	V1302-2	5	E	+	5E+	G	V1354	V1354-2	5	E	+	5E+	G
V1302	V1302-3	5	E	+	5E+	G	V1355	V1355-1	1	C	+	1C+	A
V1303	V1303-1	3	A	+	3A+	G	V1355	V1355-2	4	E	+	4E+	G
V1303	V1303-2	5	E	+	5E+	G	V1356	V1356-1	5	D	+	5D+	G
V1303	V1303-3	5	E	+	5E+	G	V1356	V1356-2	5	D	+	5D+	G
V1304	V1304-1	4	A	+	4A+	G	V1356	V1356-3	2	C	+	2C+	M
V1304	V1304-2	4	A	+	4A+	G	V1357	V1357-1	5	D	+	5D+	G
V1305	V1305-1	5	A	+	5A+	G	V1357	V1357-2	5	D	+	5D+	G
V1305	V1305-2	4	A	+	4A+	G	V1357	V1357-3	2	C	+	2C+	M
V1306	V1306-1	5	A	+	5A+	G	V136	V136-1	4	F	-	4F-	GG
V1306	V1306-2	4	A	+	4A+	G	V1366	V1366-01	4	A	+	4A+	G
V1307	V1307-1	5	A	+	5A+	G	V1367	V1367-01	4	A	+	4A+	G
V1307	V1307-2	4	A	+	4A+	G	V1368	V1368-01	4	A	+	4A+	G
V1308	V1308-1	4	A	+	4A+	G	V1369	V1369-01	2	A	+	2A+	A
V1309	V1309-1	4	A	+	4A+	G	V137	V137-1	4	E	-	4E-	GG
V1310	V1310-1	4	A	+	4A+	G	V1371	V1371-01	2	A	+	2A+	A
V131	V131-1	3	E	-	3E-	GG	V1372	V1372-01	3	A	+	3A+	G
V1311	V1311-1	4	A	+	4A+	G	V1373	V1373-01	4	A	+	4A+	G
V1312	V1312-1	4	E	+	4E+	G	V1374	V1374-01	3	A	+	3A+	G
V1312	V1312-2	5	E	+	5E+	G	V1375	V1375-01	4	A	+	4A+	G
V1313	V1313-1	5	E	+	5E+	G	V1376	V1376-01	3	A	+	3A+	G
V1313	V1313-2	4	E	+	4E+	G	V1378	V1378-01	3	A	+	3A+	G
V1379	V1379-01	2	A	+	2A+	A	V1429	V1429-1	4	A	+	4A+	G
V1380	V1380-1	1	A	+	1A+	AA	V1430	V1430-1	3	A	+	3A+	G
V138	V138-1	4	E	+	4E+	G	V143	V143-1	4	D	-	4D-	G
V1381	V1381-1	1	E	+	1E+	G	V1431	V1431-1	3	A	+	3A+	G
V1381	V1381-2	1	E	+	1E+	G	V143	V143-2	2	C	+	2C+	M
V1382	V1382-1	5	E	+	5E+	G	V1432	V1432-1	5	A	+	5A+	G
V1383	V1383-1	5	E	+	5E+	G	V1433	V1433-1	4	C	+	4C+	G
V1384	V1384-1	4	A	+	4A+	G	V1434	V1434-1	4	C	+	4C+	G
V1385	V1385-1	5	D	+	5D+	G	V1435	V1435-1	4	C	+	4C+	G
V1386	V1386-1	3	A	+	3A+	G	V1435	V1435-2	1	E	+	1E+	G
V1386	V1386-2	3	A	+	3A+	G	V1436	V1436-1	5	A	+	5A+	G
V1387	V1387-1	2	A	+	2A+	A	V1438	V1438-1	5	A	+	5A+	G
V1388	V1388-1	4	D	+	4D+	G	V1439	V1439-1	4	A	+	4A+	G
V1389	V1389-1	5	D	+	5D+	G	V1440	V1440-1	5	A	+	5A+	G
V1390	V1390-1	4	D	+	4D+	G	V144	V144-1	4	E	-	4E-	GG
V139	V139-1	4	E	-	4E-	GG	V1441	V1441-1	4	A	+	4A+	G
V1391	V1391-1	4	D	+	4D+	G	V1442	V1442-1	4	A	+	4A+	G
V1392	V1392-1	5	A	+	5A+	G	V1443	V1443-1	3	A	+	3A+	G
V1393	V1393-1	5	A	+	5A+	G	V1444	V1444-1	5	A	+	5A+	G
V1394	V1394-1	5	A	+	5A+	G	V1445	V1445-1	3	A	+	3A+	G
V1395	V1395-1	5	A	+	5A+	G	V1446	V1446-01	4	A	+	4A+	G
V1396	V1396-1	5	A	+	5A+	G	V1447	V1447-01	5	B	+	5B+	G
V1397	V1397-1	5	A	+	5A+	G	V1449	V1449-01	5	A	+	5A+	G
V1398	V1398-1	5	A	+	5A+	G	V1450	V1450-01	5	A	+	5A+	G
V1399	V1399-1	5	A	+	5A+	G	V145	V145-1	4	E	-	4E-	GG
V1400	V1400-1	5	A	+	5A+	G	V1451	V1451-01	5	A	+	5A+	G
V140	V140-1	2	C	+	2C+	M	V1452	V1452-01	5	A	+	5A+	G
V1401	V1401-01	5	D	+	5D+	G	V1453	V1453-1	5	A	+	5A+	G
V140	V140-2	4	E	-	4E-	GG	V1454	V1454-1	2	D	+	2D+	M
V1402	V1402-1	5	A	+	5A+	G	V1455	V1455-1	3	D	-	3D-	G
V1402	V1402-2	5	A	+	5A+	G	V1456	V1456-1	3	D	-	3D-	G
V1403	V1403-1	5	A	+	5A+	G	V1457	V1457-1	3	D	+	3D+	G
V1403	V1403-2	5	D	-	5D-	G	V1458	V1458-1	4	D	+	4D+	G
V1404	V1404-1	5	A	+	5A+	G	V1459	V1459-1	1	B	+	1B+	AA
V1404	V1404-2	5	D	+	5D+	G	V1460	V1460-1	1	B	+	1B+	AA
V1405	V1405-1	5	A	+	5A+	G	V146	V146-1	4	E	-	4E-	GG
V1405	V1405-2	5	D	+	5D+	G	V1461	V1461-1	3	E	+	3E+	G
V1406	V1406-1	5	A	+	5A+	G	V1461	V1461-2	1	B	+	1B+	AA
V1406	V1406-6	5	D	+	5D+	G	V1462	V1462-1	1	E	+	1E+	G
V1407	V1407-1	4	A	-	4A-	G	V1463	V1463-1	1	D	+	1D+	A
V1408	V1408-1	3	E	-	3E-	GG	V1464	V1464-1	1	B	+	1B+	AA
V1409	V1409-1	4	E	+	4E+	G	V1465	V1465-1	1	B	+	1B+	AA
V1409	V1409-2	1	B	+	1B+	AA	V1466	V1466-1	4	E	+	4E+	G
V1410	V1410-1	4	E	+	4E+	G	V1467	V1467-1	5	D	+	5D+	G
V1410	V1410-2	1	B	+	1B+	AA	V1468	V1468-1	5	E	+	5E+	G
V141	V141-1	2	C	+	2C+	M	V1469	V1469-1	5	E	+	5E+	G
V1411	V1411-1	4	D	+	4D+	G	V1470	V1470-1	5	E	+	5E+	G
V1411	V1411-2	2	C	+	2C+	M	V147	V147-1	4	E	-	4E-	GG
V1411	V1411-3	5	E	+	5E+	G	V1471	V1471-1	5	E	+	5E+	G
V1411	V1411-4	1	E	+	1E+	G	V147	V147-2	2	C	+	2C+	M
V141	V141-2	5	E	-	5E-	GG	V1472	V1472-1	5	E	+	5E+	G

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ID village	Source	Stratum time	Stratum price	Evaluated quality	Classification intégr	Type
V1412	V1412-1	5	D	+	5D+	G
V1413	V1413-1	5	D	+	5D+	G
V1414	V1414-1	4	E	+	4E+	G
V1414	V1414-2	5	F	+	5F+	G
V1415	V1415-1	4	E	+	4E+	G
V1415	V1415-2	5	F	+	5F+	G
V1416	V1416-1	4	E	+	4E+	G
V1417	V1417-1	4	E	+	4E+	G
V1418	V1418-1	5	E	+	5E+	G
V1419	V1419-1	3	E	+	3E+	G
V1420	V1420-1	3	E	+	3E+	G
V142	V142-1	5	E	-	5E-	GG
V1421	V1421-1	3	E	+	3E+	G
V142	V142-2	2	C	+	2C+	M
V1422	V1422-1	1	A	+	1A+	AA
V1423	V1423-1	1	A	+	1A+	AA
V1424	V1424-1	1	A	+	1A+	AA
V1424	V1424-2	1	A	+	1A+	AA
V1424	V1424-3	4	E	+	4E+	G
V1425	V1425-1	1	A	+	1A+	AA
V1425	V1425-2	1	A	+	1A+	AA
V1425	V1425-3	4	E	+	4E+	G
V1426	V1426-1	3	E	-	3E-	GG
V1427	V1427-1	3	E	-	3E-	GG
V1428	V1428-1	3	E	-	3E-	GG
V276	V276-1	1	C	+	1C+	A
V276	V276-2	1	E	+	1E+	G
V277	V277-1	1	C	+	1C+	A
V277	V277-2	3	A	n.d.	3A	n.d.
V277	V277-3	4	A	-	4A-	G
V278	V278-1	2	C	+	2C+	M
V278	V278-2	5	A	-	5A-	G
V279	V279-1	2	C	+	2C+	M
V279	V279-2	4	A	-	4A-	G
V280	V280-1	1	C	+	1C+	A
V280	V280-2	4	A	-	4A-	G
V281	V281-1	1	C	+	1C+	A
V281	V281-2	2	A	+	2A+	A
V281	V281-3	4	A	-	4A-	G
V282	V282-1	5	E	+	5E+	G
V282	V282-2	5	E	-	5E-	GG
V283	V283-1	5	E	+	5E+	G
V283	V283-2	5	E	-	5E-	GG
V284	V284-1	5	E	+	5E+	G
V284	V284-2	5	E	-	5E-	GG
V285	V285-1	4	C	+	4C+	G
V285	V285-2	4	A	-	4A-	G
V285	V285-3	3	C	+	3C+	G
V286	V286-1	2	C	+	2C+	M
V286	V286-2	3	A	-	3A-	G
V287	V287-1	1	C	+	1C+	A
V287	V287-2	3	A	-	3A-	G
V288	V288-1	1	C	+	1C+	A
V288	V288-2	3	A	-	3A-	G
V289	V289-1	3	C	+	3C+	G
V289	V289-2	2	A	-	2A-	G
V290	V290-1	1	C	+	1C+	A
V290	V290-2	3	A	-	3A-	G
V291	V291-1	5	A	-	5A-	G
V292	V292-1	5	A	-	5A-	G
V293	V293-1	5	A	-	5A-	G
V294	V294-1	1	C	+	1C+	A
V294	v294-2	3	A	-	3A-	G
V295	V295-1	2	C	+	2C+	M
V295	V295-2	3	A	-	3A-	G
V295	V295-3	1	D	+	1D+	A
V295	V295-4	1	E	+	1E+	G
V296	V296-1	1	C	+	1C+	A
V296	V296-2	2	A	-	2A-	G
V297	V297-1	2	A	-	2A-	G
V297	V297-2	1	C	+	1C+	A
V298	V298-1	2	A	-	2A-	G
V298	V298-2	1	C	+	1C+	A
V299	V299-1	2	A	-	2A-	G
V299	V299-2	1	C	+	1C+	A
V300	V300-1	2	A	-	2A-	G
V300	V300-2	1	C	+	1C+	A
V324	V324-1	1	C	+	1C+	A
V325	V325-1	1	C	+	1C+	A
V326	V326-1	1	C	+	1C+	A
V678	V378-1	2	A	+	2A+	A
V405	V405-1	2	A	-	2A-	G
V405	V405-2	1	C	-	1C-	G
V407	V407-1	3	A	-	3A-	G
V407	V407-2	5	E	+	5E+	G
V408	V408-1	1	C	+	1C+	A
V409	V409-1	1	C	+	1C+	A
V410	V410-1	1	C	+	1C+	A
V411	V411-1	1	A	+	1A+	AA
V411	V411-2	5	A	-	5A-	G
V412	V412-1	1	C	+	1C+	A
V412	V412-2	3	A	-	3A-	G
V413	V413-1	3	A	+	3A+	G
V1473	V1473-1	5	A	+	5A+	G
V1475	V1475-1	5	A	+	5A+	G
V1476	V1476-1	1	C	+	1C+	A
V1477	V1477-1	5	D	+	5D+	G
V148	V148-1	4	E	-	4E-	GG
V148	V148-2	2	C	+	2C+	M
V149	V149-1	4	E	+	4E+	G
V149	V149-2	2	C	+	2C+	M
V150	V150-1	4	E	-	4E-	GG
V150	V150-2	1	C	+	1C+	A
V151	V151-1	4	E	-	4E-	GG
V151	V151-2	1	C	+	1C+	A
V152	V152-1	4	E	-	4E-	GG
V152	V152-2	1	C	+	1C+	A
V153	V153-1	4	E	-	4E-	GG
V153	V153-2	2	C	+	2C+	M
V154	V154-1	4	E	-	4E-	GG
V154	V154-2	2	C	+	2C+	M
V155	V155-1	1	A	n.d.	1A	n.d.
V156	V156-1	1	A	n.d.	1A	n.d.
V157	V157-1	1	A	n.d.	1A	n.d.
V274	V274-1	1	C	+	1C+	A
V274	V274-2	1	E	+	1E+	G
V275	V275-1	1	C	+	1C+	A
V275	V275-2	1	E	+	1E+	G
V418	V418-1	3	A	-	3A-	G
V418	V418-2	3	C	+	3C+	G
V419	V419-1	3	C	+	3C+	G
V419	V419-2	3	A	-	3A-	G
V420	V420-1	3	C	+	3C+	G
V420	V420-2	3	A	-	3A-	G
V421	V421-1	3	A	-	3A-	G
V421	V421-2	3	C	+	3C+	G
V422	V422-1	5	A	-	5A-	G
V422	V422-2	1	A	-	1A-	G
V423	V423-1	3	A	-	3A-	G
V423	V423-2	1	C	+	1C+	A
V425	V425-1	3	A	-	3A-	G
V425	V425-2	1	C	+	1C+	A
V426	V426-1	1	C	+	1C+	A
V426	V426-2	3	A	-	3A-	G
V427	V427-1	2	A	-	2A-	G
V427	V427-2	5	A	-	5A-	G
V428	V428-1	2	A	-	2A-	G
V428	V428-2	5	A	-	5A-	G
V429	V429-1	5	A	-	5A-	G
V430	V430-1	3	A	-	3A-	G
V430	V430-2	2	E	+	2E+	G
V431	V431-1	3	A	-	3A-	G
V431	V431-2	3	C	+	3C+	G
V431	V431-3	5	E	-	5E-	GG
V432	V432-1	2	E	+	2E+	G
V432	V432-2	2	A	-	2A-	G
V432	V432-3	5	E	-	5E-	GG
V434	V434-1	2	A	-	2A-	G
V434	V434-2	2	C	+	2C+	M
V434	V434-3	5	E	-	5E-	GG
V435	V435-1	3	A	-	3A-	G
V435	V435-2	3	C	+	3C+	G
V437	V437-1	5	A	-	5A-	G
V437	V437-2	3	A	-	3A-	G
V438	V438-1	5	A	-	5A-	G
V438	V438-2	3	A	-	3A-	G
V438	V438-3	2	C	+	2C+	M
V439	V439-1	1	C	+	1C+	A
V440	V440-1	3	A	-	3A-	G
V441	V441-1	1	C	+	1C+	A
V441	V441-2	3	A	-	3A-	G
V442	V442-1	1	B	+	1B+	AA
V442	V442-2	5	E	+	5E+	G
V443	V443-1	1	B	+	1B+	AA
V443	V443-2	5	E	+	5E+	G
V444	V444-1	1	B	+	1B+	AA
V444	V444-2	5	E	+	5E+	G
V445	V445-1	1	B	+	1B+	AA
V445	V445-2	5	E	+	5E+	G
V446	V446-1	1	B	+	1B+	AA
V446	V446-2	4	A	-	4A-	G
V446	V446-3	1	E	+	1E+	G
V447	V447-1	1	B	+	1B+	AA
V447	V447-2	5	E	+	5E+	G
V448	V448-1	1	B	+	1B+	AA
V448	V448-2	4	A	-	4A-	G
V448	V448-3	1	E	+	1E+	G
V449	V449-1	4	D	+	4D+	G
V450	V450-1	4	D	+	4D+	G
V451	V451-1	4	D	+	4D+	G
V452	V452-1	4	D	+	4D+	G
V453	V453-1	1	B	+	1B+	AA
V454	V454-1	1	B	+	1B+	AA
V455	V455-1	5	D	+	5D+	G
V455	V455-2	1	A	-	1A-	G
V455	V455-3	1	B	+	1B+	AA

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ID village	Source	Stratum time	Stratum price	Evaluated quality	Classification intégr	Type		ID village	Source	Stratum time	Stratum price	Evaluated quality	Classification intégr	Type
V414	V414-1	3	A	-	3A-	G		V456	V456-1	1	B	+	1B+	AA
V414	V414-2	1	E	-	1E-	G		V457	V457-1	1	B	+	1B+	AA
V415	V415-1	3	A	-	3A-	G		V457	V457-2	4	A	-	4A-	G
V415	V415-2	1	E	+	1E+	G		V459	V459-1	1	B	+	1B+	AA
V416	V416-1	3	A	-	3A-	G		V460	V460-1	1	B	+	1B+	AA
V416	V416-2	1	E	+	1E+	G		V461	V461-1	1	B	+	1B+	AA
V417	V417-1	3	A	-	3A-	G		V462	V462-1	1	D	+	1D+	A
V417	V417-2	3	C	-	3C-	G		V463	V463-1	5	D	+	5D+	G
V463	V463-2	1	E	+	1E+	G		V518	V518-2	2	A	+	2A+	A
V464	V464-1	5	D	+	5D+	G		V519	V519-1	3	A	+	3A+	G
V464	V464-2	1	E	+	1E+	G		V520	V520-1	3	A	+	3A+	G
V465	V465-1	5	D	+	5D+	G		V521	V521-1	3	A	+	3A+	G
V466	V466-1	5	D	+	5D+	G		V522	V522-1	3	A	+	3A+	G
V467	V467-1	5	D	+	5D+	G		V523	V523-1	3	A	+	3A+	G
V467	V467-2	1	E	+	1E+	G		V524	V524-1	3	A	+	3A+	G
V468	V468-1	1	D	+	1D+	A		V525	V525-1	3	A	+	3A+	G
V470	V470-1	1	B	+	1B+	AA		V526	V526-1	3	A	+	3A+	G
V470	V470-2	4	A	-	4A-	G		V527	V527-1	3	A	+	3A+	G
V471	V471-1	1	B	+	1B+	AA		V528	V528-1	3	A	+	3A+	G
V471	V471-2	4	A	-	4A-	G		V529	V529-1	3	A	+	3A+	G
V472	V472-1	1	B	+	1B+	AA		V530	V530-1	3	A	+	3A+	G
V472	V472-2	4	A	-	4A-	G		V531	V531-1	2	A	-	2A-	G
V473	V473-1	1	B	+	1B+	AA		V531	V531-2	3	A	+	3A+	G
V473	V473-2	4	A	n.d.	4A	n.d.		V532	V532-1	2	A	+	2A+	A
V474	V474-1	1	B	+	1B+	AA		V532	V532-2	3	A	+	3A+	G
V474	V474-2	4	A	-	4A-	G		V533	V533-1	2	A	-	2A-	G
V475	V475-1	3	A	+	3A+	G		V533	V533-2	3	A	+	3A+	G
V475	V475-2	3	A	-	3A-	G		V534	V534-1	2	A	-	2A-	G
V475	V475-3	1	E	+	1E+	G		V534	V534-2	3	A	+	3A+	G
V476	V476-1	3	A	+	3A+	G		V535	V535-1	2	A	-	2A-	G
V476	V476-2	5	A	-	5A-	G		V535	V535-2	3	A	+	3A+	G
V477	V477-1	3	A	+	3A+	G		V536	V536-1	2	A	-	2A-	G
V478	V478-1	3	A	+	3A+	G		V536	V536-2	3	A	+	3A+	G
V478	V478-2	3	A	-	3A-	G		V537	V537-1	2	A	-	2A-	G
V478	V478-3	1	E	+	1E+	G		V537	V537-2	3	A	+	3A+	G
V479	V479-1	3	A	+	3A+	G		V538	V538-1	3	D	+	3D+	G
V479	V479-2	3	A	-	3A-	G		V543	V543-1	3	A	-	3A-	G
V479	V479-3	1	E	+	1E+	G		V546	V546-1	4	A	+	4A+	G
V480	V480-1	1	B	+	1B+	AA		V547	V547-1	4	A	+	4A+	G
V481	V481-1	1	B	+	1B+	AA		V548	V548-1	3	A	+	3A+	G
V482	V482-1	1	B	+	1B+	AA		V549	V549-1	1	C	+	1C+	A
V483	V483-1	1	B	+	1B+	AA		V550	V550-1	4	E	-	4E-	GG
V484	V484-1	4	E	-	4E-	GG		V551	V551-1	4	E	+	4E+	G
V485	V485-1	4	E	-	4E-	GG		V552	V552-1	4	E	-	4E-	GG
V485	V485-2	2	D	-	2D-	G		V553	V553-1	4	E	+	4E+	G
V486	V486-1	3	A	-	3A-	G		V554	V554-1	4	E	-	4E-	GG
V486	V486-2	1	D	+	1D+	A		V555	V555-1	4	E	+	4E+	G
V487	V487-1	3	A	-	3A-	G		V556	V556-1	4	E	+	4E+	G
V487	V487-2	2	D	+	2D+	M		V557	V557-1	4	E	+	4E+	G
V488	V488-1	3	A	-	3A-	G		V558	V558-1	4	E	+	4E+	G
V488	V488-2	2	D	+	2D+	M		V566	V566-1	3	E	+	3E+	G
V489	V489-1	1	C	+	1C+	A		V568	V568-1	3	E	-	3E-	GG
V489	V489-2	5	E	+	5E+	G		V570	V570-1	3	E	+	3E+	G
V489	V489-3	1	D	+	1D+	A		V571	V571-1	3	E	+	3E+	G
V490	V490-1	2	B	+	2B+	A		V572	V572-1	3	E	n.d.	3E	n.d.
V490	V490-2	5	E	+	5E+	G		V574	V574-1	3	E	+	3E+	G
V490	V490-3	3	E	+	3E+	G		V576	V576-1	3	A	+	3A+	G
V491	V491-1	5	E	+	5E+	G		V576	V576-2	4	E	+	4E+	G
V491	V491-2	1	E	+	1E+	G		V578	V578-1	3	A	+	3A+	G
V492	V492-1	5	E	+	5E+	G		V578	V578-2	5	F	+	5F+	G
V492	V492-2	2	E	+	2E+	G		V579	V579-1	3	A	+	3A+	G
V493	V493-1	1	B	+	1B+	AA		V580	V580-1	3	A	+	3A+	G
V493	V493-2	2	A	+	2A+	A		V582	V582-1	3	A	+	3A+	G
V493	V493-3	2	B	+	2B+	A		V589	V589-1	3	C	+	3C+	G
V493	V493-4	5	E	+	5E+	G		V589	V589-2	2	A	-	2A-	G
V494	V494-1	5	E	+	5E+	G		V589	V589-3	5	E	+	5E+	G
V494	V494-2	1	E	+	1E+	G		V590	V590-1	3	C	+	3C+	G
V495	V495-1	5	E	+	5E+	G		V590	V590-2	2	A	-	2A-	G
V495	V495-2	1	E	+	1E+	G		V590	V590-3	5	E	+	5E+	G
V495	V495-3	1	B	+	1B+	AA		V591	V591-1	3	C	+	3C+	G
V496	V496-1	5	E	+	5E+	G		V591	V591-2	2	A	-	2A-	G
V497	V497-1	5	E	+	5E+	G		V591	V591-3	5	E	+	5E+	G
V498	V498-1	5	E	+	5E+	G		V593	V593-1	2	C	+	2C+	M
V498	V498-2	5	D	-	5D-	G		V593	V593-2	1	A	-	1A-	G
V499	V499-1	5	E	+	5E+	G		V593	V593-3	5	E	+	5E+	G
V500	V500-1	5	E	+	5E+	G		V599	V599-1	2	A	+	2A+	A
V510	V510-1	2	A	-	2A-	G		V599	V599-2	2	A	-	2A-	G
V510	V510-2	5	E	-	5E-	GG		V600	V600-1	1	B	+	1B+	AA
V515	V515-1	5	E	+	5E+	G		V600	V600-2	2	A	-	2A-	G
V516	V516-1	1	A	+	1A+	AA		V600	V600-3	4	E	+	4E+	G
V516	V516-2	2	A	+	2A+	A		V601	V601-1	5	A	n.d.	5A	n.d.
V517	V517-1	2	A	+	2A+	A		V602	V602-1	5	D	+	5D+	G
V517	V517-2	2	A	+	2A+	A		V603	V603-1	5	D	+	5D+	G
V518	V518-1	2	A	+	2A+	A		V604	V604-1	5	D	n.d.	5D	n.d.
V605	V605-1	5	D	+	5D+	G		V679	V679-1	2	A	+	2A+	A
V606	V606-1	1	D	+	1D+	A		V679	V679-2	1	D	+	1D+	A
V607	V607-1	1	D	+	1D+	A		V679	V679-3	5	E	+	5E+	G
V608	V608-1	4	E	-	4E-	GG		V680	V680-1	2	A	+	2A+	A
V609	V609-1	4	E	-	4E-	GG		V681	V681-1	3	E	+	3E+	G
V610	V610-1	2	A	-	2A-	G		V682	V682-1	3	A	+	3A+	G
V611	V611-1	4	F	-	4F-	GG		V683	V683-1	3	E	+	3E+	G
V612	V612-01	5	D	+	5D+	G		V684	V684-1	3	A	+	3A+	G
V612	V612-02	5	A	+	5A+	G		V685	V685-1	2	A	-	2A-	G

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ID village	Source	Stratum time	Stratum price	Evaluated quality	Classification intégr	Type		ID village	Source	Stratum time	Stratum price	Evaluated quality	Classification intégr	Type
V613	V613-1	5	A	+	5A+	G		V703	V703-1	5	D	+	5D+	G
V614	V614-01	5	A	+	5A+	G		V704	V704-1	5	D	+	5D+	G
V615	V615-01	4	E	+	4E+	G		V705	V705-1	5	D	+	5D+	G
V616	V616-1	4	E	+	4E+	G		V706	V706-01	5	D	+	5D+	G
V617	V617-1	4	E	+	4E+	G		V707	V707-01	5	D	+	5D+	G
V618	V618-1	3	E	+	3E+	G		V709	V709-1	5	A	+	5A+	G
V619	V619-1	4	E	+	4E+	G		V710	V710-1	5	D	+	5D+	G
V620	V620-1	4	E	+	4E+	G		V711	V711-1	2	E	+	2E+	G
V621	V621-01	5	E	+	5E+	G		V711	V711-2	4	E	+	4E+	G
V622	V622-1	5	E	+	5E+	G		V712	V712-01	2	D	+	2D+	M
V623	V623-1	5	E	+	5E+	G		V713	V713-1	2	D	+	2D+	M
V624	V624-1	5	E	+	5E+	G		V713	V713-2	4	E	+	4E+	G
V625	V625-1	5	E	+	5E+	G		V714	V714-1	5	E	+	5E+	G
V626	V626-1	5	A	+	5A+	G		V714	V714-2	5	E	+	5E+	G
V627	V627-1	5	A	+	5A+	G		V715	V715-01	5	E	+	5E+	G
V628	V628-1	5	A	+	5A+	G		V716	V716-1	5	E	+	5E+	G
V629	V629-1	5	A	+	5A+	G		V716	V716-2	5	A	+	5A+	G
V630	V630-01	5	A	+	5A+	G		V717	V717-1	5	A	+	5A+	G
V632	V632-01	3	E	-	3E-	GG		V717	V717-2	5	E	+	5E+	G
V633	V633-01	3	E	-	3E-	GG		V718	V718-1	5	A	+	5A+	G
V634	V634-1	4	E	-	4E-	GG		V718	V718-2	5	E	+	5E+	G
V635	V635-01	3	E	-	3E-	GG		V719	V719-1	5	A	+	5A+	G
V636	V636-1	3	E	-	3E-	GG		V719	V719-2	5	E	+	5E+	G
V637	V637-1	3	E	-	3E-	GG		V720	V720-1	5	E	+	5E+	G
V638	V638-01	5	D	+	5D+	G		V720	V720-2	5	A	+	5A+	G
V639	V639-1	5	D	+	5D+	G		V721	V721-1	5	A	+	5A+	G
V640	V640-1	5	D	+	5D+	G		V721	V721-2	5	E	+	5E+	G
V641	V641-1	5	D	+	5D+	G		V722	V722-1	5	A	+	5A+	G
V641	V641-2	5	A	+	5A+	G		V722	V722-2	5	E	+	5E+	G
V642	V642-1	5	D	+	5D+	G		V723	V723-1	5	A	+	5A+	G
V643	V643-1	5	D	+	5D+	G		V723	V723-2	5	E	+	5E+	G
V644	V644-01	5	D	+	5D+	G		V724	V724-1	5	A	+	5A+	G
V645	V645-1	5	D	+	5D+	G		V724	V724-2	5	E	+	5E+	G
V646	V646-1	5	D	+	5D+	G		V725	V725-1	5	A	+	5A+	G
V647	V647-1	5	D	+	5D+	G		V725	V725-2	5	E	+	5E+	G
V648	V648-1	5	D	+	5D+	G		V726	V726-1	5	A	+	5A+	G
V649	V649-01	3	E	-	3E-	GG		V726	V726-2	5	E	+	5E+	G
V654	V654-1	3	E	-	3E-	GG		V727	V727-1	5	A	+	5A+	G
V655	V655-1	3	E	-	3E-	GG		V727	V727-2	5	E	+	5E+	G
V656	V656-1	3	E	-	3E-	GG		V728	V728-1	5	A	+	5A+	G
V657	V657-1	3	E	-	3E-	GG		V728	V728-2	4	E	-	4E-	GG
V658	V658-1	3	E	-	3E-	GG		V729	V729-1	5	A	+	5A+	G
V659	V659-01	3	E	-	3E-	GG		V729	V729-2	4	D	-	4D-	G
V660	V660-1	3	E	-	3E-	GG		V730	V730-1	5	A	+	5A+	G
V661	V661-1	3	E	-	3E-	GG		V730	V730-2	5	E	+	5E+	G
V662	V662-1	3	E	-	3E-	GG		V731	V731-1	5	A	+	5A+	G
V663	V663-1	3	E	-	3E-	GG		V731	V731-2	4	E	-	4E-	GG
V664	V664-1	2	A	+	2A+	A		V732	V732-01	5	A	+	5A+	G
V665	V665-1	2	A	+	2A+	A		V732	V732-02	4	D	-	4D-	G
V666	V666-1	2	A	+	2A+	A		V733	V733-01	5	A	+	5A+	G
V667	V667-1	2	A	+	2A+	A		V734	V734-01	5	A	n.d.	5A	n.d.
V668	V668-1	2	A	+	2A+	A		V734	V734-02	4	n.d.	n.d.	4	n.d.
V669	V669-1	2	B	+	2B+	A		V735	V735-01	5	n.d.	+	5+	n.d.
V669	V669-2	2	A	-	2A-	G		V735	V735-02	4	D	-	4D-	G
V670	V670-1	2	A	+	2A+	A		V736	V736-1	5	A	+	5A+	G
V671	V671-1	2	A	+	2A+	A		V736	V736-2	4	E	-	4E-	GG
V672	V672-1	2	A	+	2A+	A		V737	V737-01	5	A	+	5A+	G
V673	V673-1	2	A	+	2A+	A		V737	V737-02	4	E	-	4E-	GG
V674	V674-1	3	A	+	3A+	G		V738	V738-1	5	A	n.d.	5A	n.d.
V674	V674-2	3	E	+	3E+	G		V738	V738-2	4	E	-	4E-	GG
V675	V675-1	2	A	+	2A+	A		V739	V739-1	5	C	+	5C+	G
V675	V675-2	1	E	+	1E+	G		V739	V739-2	5	D	+	5D+	G
V676	V676-1	2	A	+	2A+	A		V739	V739-3	5	B	-	5B-	G
V676	V676-2	1	E	+	1E+	G		V739	V739-4	3	A	n.d.	3A	n.d.
V677	V677-1	2	A	+	2A+	A		V740	V740-1	1	C	+	1C+	A
V677	V677-2	2	E	+	2E+	G		V740	V740-2	5	E	-	5E-	GG
V678	V678-2	2	E	+	2E+	G		V741	V741-1	1	C	+	1C+	A
V741	V741-2	5	E	-	5E-	GG		V802	V802-01	5	D	-	5D-	G
V742	V742-1	1	C	+	1C+	A		V805	V805-01	4	D	-	4D-	G
V742	V742-2	5	E	-	5E-	GG		V805	V805-02	1	D	-	1D-	G
V743	V743-1	1	C	+	1C+	A		V810	V810-1	5	D	+	5D+	G
V743	V743-2	5	E	-	5E-	GG		V810	V810-2	1	D	+	1D+	A
V744	V744-1	1	C	+	1C+	A		V811	V811-1	5	D	+	5D+	G
V744	V744-2	5	E	-	5E-	GG		V811	V811-2	1	D	+	1D+	A
V745	V745-1	1	C	+	1C+	A		V812	V812-1	5	D	+	5D+	G
V745	V745-2	5	E	-	5E-	GG		V812	V812-2	1	D	+	1D+	A
V746	V746-01	5	D	+	5D+	G		V813	V813-1	5	D	+	5D+	G
V747	V747-1	5	D	+	5D+	G		V813	V813-2	1	D	+	1D+	A
V748	V748-01	4	D	+	4D+	G		V814	V814-1	1	D	+	1D+	A
V749	V749-1	5	D	+	5D+	G		V815	V815-1	1	D	+	1D+	A
V750	V750-1	4	D	+	4D+	G		V816	V816-1	1	E	+	1E+	G
V751	V751-1	4	D	+	4D+	G		V817	V817-1	1	D	+	1D+	A
V752	V752-1	5	D	+	5D+	G		V818	V818-01	1	D	+	1D+	A
V753	V753-1	5	D	+	5D+	G		V819	V819-1	1	E	+	1E+	G
V754	V754-01	5	D	+	5D+	G		V828	V828-1	3	E	-	3E-	GG
V755	V755-1	5	D	+	5D+	G		V828	V828-2	2	A	-	2A-	G
V756	V756-1	5	E	-	5E-	GG		V832	V832-1	4	E	-	4E-	GG
V756	V756-2	5	E	+	5E+	G		V832	V832-2	2	A	-	2A-	G
V757	V757-1	4	E	-	4E-	GG		V837	V837-1	5	F	+	5F+	G
V757	V757-2	5	E	+	5E+	G		V837	V837-2	4	F	+	4F+	G
V758	V758-1	5	E	-	5E-	GG		V838	V838-1	5	F	+	5F+	G
V758	V758-2	5	E	+	5E+	G		V838	V838-2	4	F	+	4F+	G
V759	V759-1	5	E	-	5E-	GG		V839	V839-1	5	F	+	5F+	G

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ID village	Source	Stratum time	Stratum price	Evaluated quality	Classifica-tion intégr	Type		ID village	Source	Stratum time	Stratum price	Evaluated quality	Classifica-tion intégr	Type
V759	V759-2	5	E	+	5E+	G		V839	V839-2	4	F	+	4F+	G
V760	V760-1	5	E	-	5E-	GG		V840	V840-1	5	F	+	5F+	G
V760	V760-2	5	E	+	5E+	G		V840	V840-2	4	F	+	4F+	G
V761	V761-1	4	E	-	4E-	GG		V841	V841-1	5	F	+	5F+	G
V761	V761-2	5	E	-	5E-	GG		V841	V841-2	4	F	+	4F+	G
V762	V762-1	5	E	-	5E-	GG		V881	V881-1	3	E	-	3E-	GG
V762	V762-2	5	E	+	5E+	G		V881	V881-2	2	A	-	2A-	G
V763	V763-1	5	E	-	5E-	GG		V882	V882-1	3	E	-	3E-	GG
V764	V764-01	4	E	+	4E+	G		V882	V882-2	2	A	-	2A-	G
V769	V769-1	2	D	+	2D+	M		V883	V883-1	3	E	-	3E-	GG
V769	V769-2	2	D	+	2D+	M		V883	V883-2	2	A	-	2A-	G
V770	V770-1	1	D	+	1D+	A		V890	V890-1	5	D	+	5D+	G
V770	V770-2	1	D	+	1D+	A		V891	V891-1	4	D	+	4D+	G
V771	V771-01	2	E	+	2E+	G		V893	V893-1	4	D	+	4D+	G
V772	V772-1	2	D	+	2D+	M		V893	V893-2	4	D	+	4D+	G
V772	V772-2	1	D	+	1D+	A		V894	V894-1	5	A	+	5A+	G
V771	V772-3	2	D	+	2D+	M		V895	V895-1	5	A	n.d.	5A	n.d.
V773	V773-1	2	D	+	2D+	M		V896	V896-1	5	A	+	5A+	G
V773	V773-2	2	D	+	2D+	M		V897	V897-1	5	A	+	5A+	G
V774	V774-1	3	D	+	3D+	G		V898	V898-1	3	A	+	3A+	G
V774	V774-2	3	D	+	3D+	G		V899	V899-1	4	A	+	4A+	G
V775	V775-01	5	E	+	5E+	G		V901	V901-1	5	D	+	5D+	G
V780	V780-01	3	A	-	3A-	G		V901	V901-2	4	D	-	4D-	G
V780	V780-02	3	D	+	3D+	G		V902	V902-1	5	A	+	5A+	G
V780	V780-03	1	n.d.	+	1+	n.d.		V902	V902-2	4	A	-	4A-	G
V783	V783-1	1	D	+	1D+	A		V903	V903-1	5	D	+	5D+	G
V783	V783-2	1	D	+	1D+	A		V903	V903-2	4	D	-	4D-	G
V784	V784-1	1	D	+	1D+	A		V904	V904-1	5	A	+	5A+	G
V785	V785-1	2	D	+	2D+	M		V904	V904-2	4	A	-	4A-	G
V785	V785-2	1	D	+	1D+	A		V905	V905-1	5	D	+	5D+	G
V786	V786-1	3	D	+	3D+	G		V905	V905-2	4	D	-	4D-	G
V786	V786-2	1	D	+	1D+	A		V916	V916-1	5	E	+	5E+	G
V787	V787-1	1	D	+	1D+	A		V917	V917-1	5	E	+	5E+	G
V787	V787-2	1	D	+	1D+	A		V918	V918-1	5	E	+	5E+	G
V788	V788-01	1	D	+	1D+	A		V919	V919-01	5	E	+	5E+	G
V788	V788-02	2	A	+	2A+	A		V920	V920-01	5	E	+	5E+	G
V789	V789-1	1	D	+	1D+	A		V921	V921-01	5	E	+	5E+	G
V789	V789-2	1	D	+	1D+	A		V922	V922-1	5	E	+	5E+	G
V790	V790-1	2	D	+	2D+	M		V923	V923-1	5	E	+	5E+	G
V790	V790-2	2	D	+	2D+	M		V924	V924-1	5	E	+	5E+	G
V791	V791-1	3	D	+	3D+	G		V925	V925-1	5	E	+	5E+	G
V791	V791-2	3	D	+	3D+	G		V926	V926-1	5	E	+	5E+	G
V792	V792-1	3	D	+	3D+	G		V927	V927-1	5	E	+	5E+	G
V792	V792-2	3	D	+	3D+	G		V969	V969-1	3	A	+	3A+	G
V793	V793-1	3	E	-	3E-	GG		V996	V996-1	3	A	+	3A+	G
V794	V794-1	3	E	-	3E-	GG		V997	V997-1	3	A	+	3A+	G
V795	V795-01	3	E	-	3E-	GG		V998	V998-1	3	A	+	3A+	G
V796	V796-1	3	E	-	3E-	GG		V998	V998-2	3	A	+	3A+	G
V800	V800-01	4	D	+	4D+	G		V999	V999-1	2	A	+	2A+	A
V800	V800-02	1	D	+	1D+	A								

Time		Water charge		Quality	
1	<= 15 min	A	0	+	Good
2	<= 1 hour	B	0< <=20	-	Bad (dirty, salty)
3	<= 3 hours	C	20< <=50		
4	<= 6 hours	D	50< <=100		
5	6 hours <	E	100< <=500		
		F	500<		

Types

AA:	**Much better condition**
A:	**Better condition**
M:	**Medium**
GG:	**Much worse condition**
G:	**Worse condition (Other than above mentioned types)**