CHAPTER 14

FUTURE WATER RESOURCES

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14.1 Groundwater Resources

14.1.1 Geophysical Exploration for Evaluating Groundwater Resources

Geophysical exploration was carried out for evaluating groundwater resources in the study area and also for assisting to delineate promising areas for drilling and taking water from springs. This survey consists of VES (Vertical Electrical Sounding) survey and 2D Imaging (Two Dimensional Resistivity Imaging) survey. VES measurements were conducted at the area supposed that deep wells will be drilled for future water supply and 2D measurements were carried out at the area for drilling shallow wells or taking water from springs.

(1) Location of Geophysical Exploration

Preparatory for the geophysical exploration, hydrogeologist of this study consulted with the persons in charge of water supply for the study area and selected the 80 survey points in consideration of their priority. 60 points in 3 districts (Sleman Regency, Yogyakarta Municipality and Bantul Regency) for VES survey and 20 in Sleman Regency for 2D imaging survey were selected. Figure 14.1.3 shows the locations of VES points and Figure 14.1.4 shows those of 2D imaging. The area name (Dusun, Desa and Kecamatan) and coordinates of measurement points are listed in Table 14.1.1 to 14.1.5.

(2) Method of Survey

VES method uses Schlumberger configuration, and 2D Imaging method uses Dipole-Dipole configuration. VES method has been usually used for groundwater exploration, and is useful to investigate simple hydrogeological structure or horizontal layers parallel with the flat ground surface. 2D imaging is relatively new technological method and can draw cross section of specific resistivity. It follows that 2D imaging is very useful method for complicated hydrogeological structure.

1) VES survey (Schlumberger configuration)

In this survey, four electrodes are placed in the ground on one line symmetrically around the measurement point. Electric current is injected through the outer electrodes (A, B), and the potential difference between the inner electrodes (M, N) is measured simultaneously. The electrodes (A, B) are moved out around the measurement point and a new measurement is taken. Figure 14.1.1 shows Schlumberger configuration. The apparent resistivity is expressed as,

$$\rho_a = \frac{\pi}{4l}\left(L^2 - l^2\right)\frac{V}{I} \qquad [L > 5\,l]$$

where, *V* is the potential difference, I is the current value, L is the distance between A and B and l is the distance between M and N.

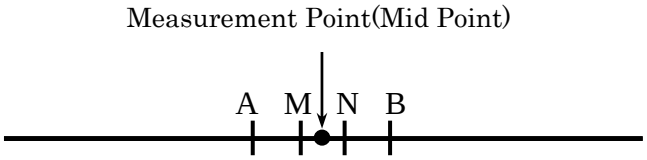


Figure 14.1.1 Schlumberger configuration

2) 2D imaging survey (Dipole-Dipole configuration)

Figure 14.1.2 shows Dipole-Dipole configuration. The measurement starts with a spacing of "a" between the C1 and C2 (and also the P1 and P2) electrodes. The first sequence of measurements is made with a value of 1 for the separation factor "n" (which is the ratio of the distance between the C2 and P1 electrodes to the C1-C2 dipole length), followed by "n" equals to 2 while keeping the C1-C2 dipole spacing fixed at "a". When "n" is equals to 2, the distance between C2 and P1 electrodes is twice the C1-C2 dipole length. To increase the depth of investigation, the spacing between the C1-C2 dipole is increased to "2a", and another series of measurements with different values of "n" is made. The apparent resistivity is expressed as,

$$\rho_a = n(n+1)(n+2)\pi a \frac{V}{I}$$

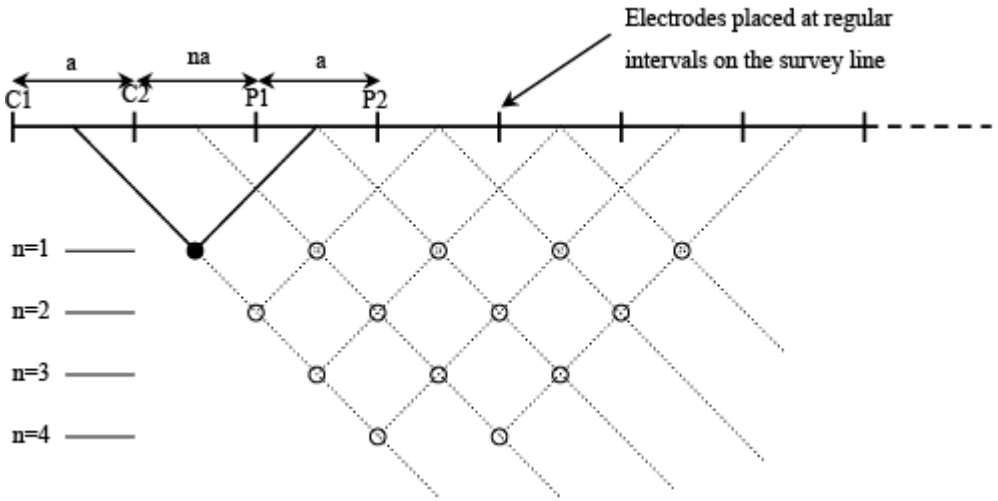


Figure 14.1.2 Dipole-Dipole configuration

The apparent resistivity data were interpreted using a 2D inversion software, and a resistivity section was made for each survey line. The hydrogeological structure can be estimated using the resistivity section

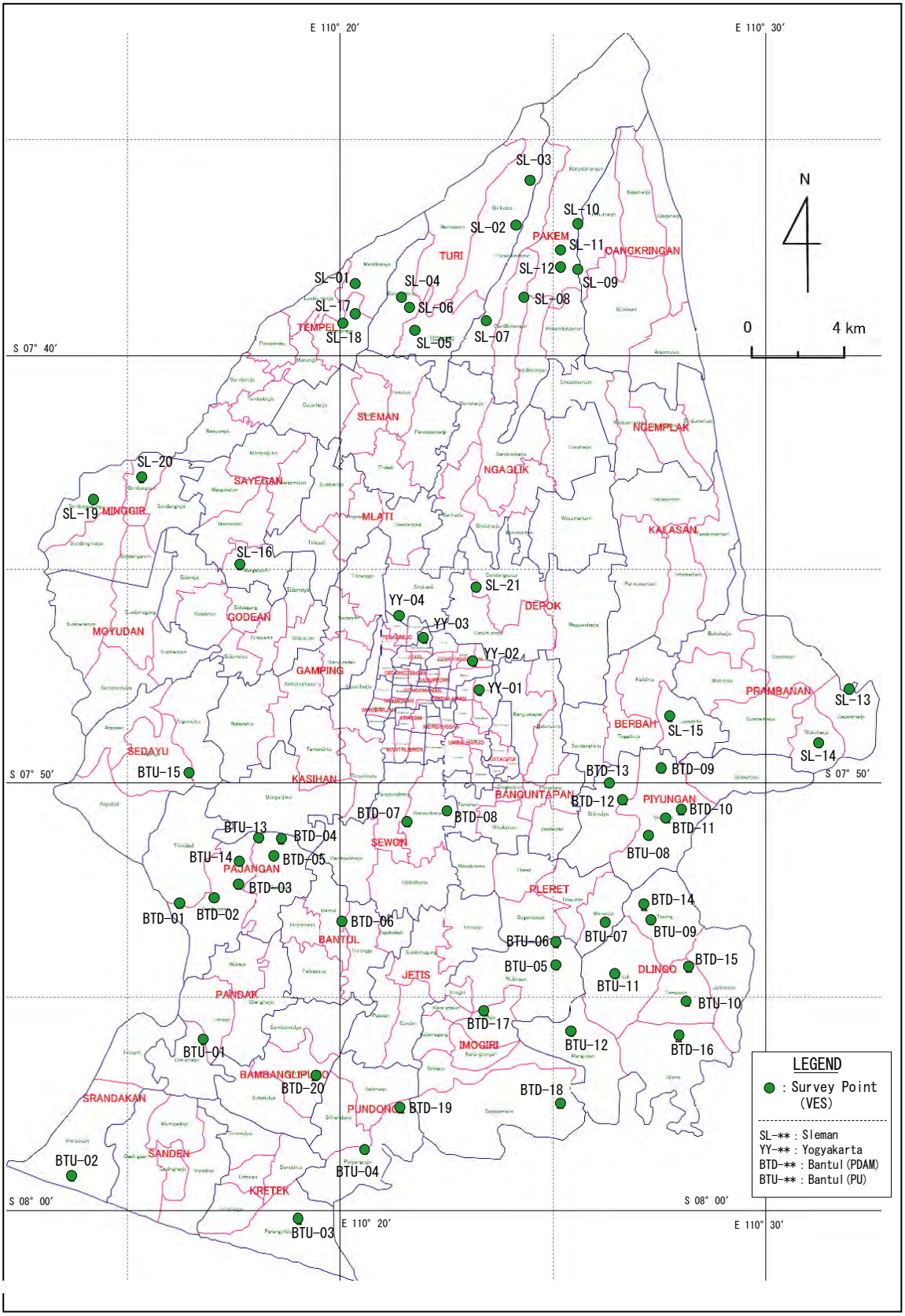


Figure 14.1.3 Location Map of Survey Points (VES)

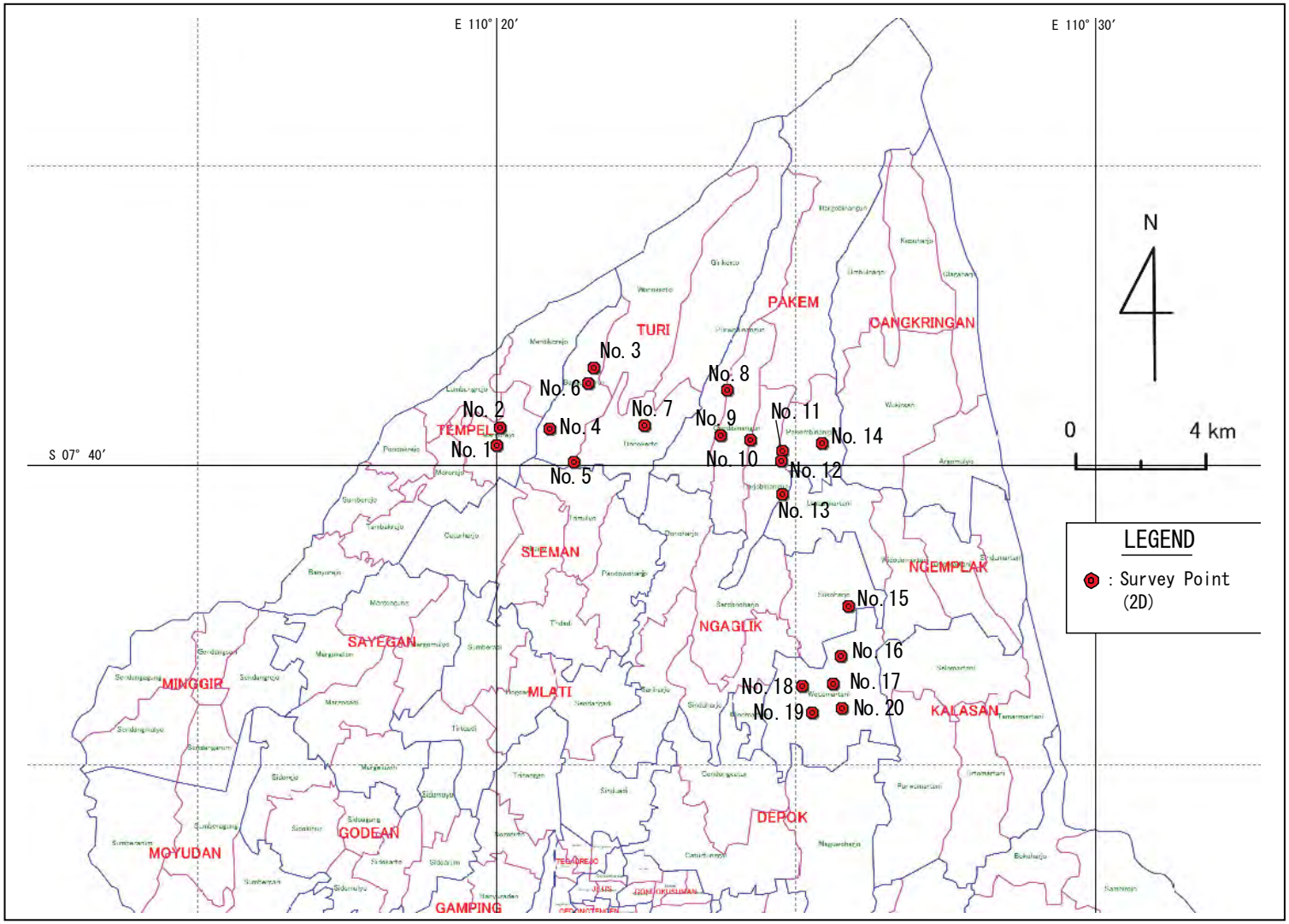


Figure 14.1.4 Location Map of Survey Points (2D)

Table 14.1.1 List of Survey Points (VES Sleman 21points)

No	DUSUN	DESA	KECAMATAN	Latitude (S)	Longitude(E)
1	Gesikan	Merdikorejo	Tempel	7^O 38’ 22.4”	110^O 20’ 21.3”
2	Kemirikebo	Girikerto	Turi	7^O 37’ 01.1”	110^O 24’ 07.6”
3	Ngandong	Girikerto	Turi	7^O 35’ 56.6”	110^O 24’ 26.6”
4	Ledoknongko	Bangunkerto	Turi	7^O 38’ 40.7”	110^O 21’ 26.0”
5	Gading	Donokerto	Turi	7^O 39’ 28.6”	110^O 22’ 44.9”
6	Bayeman	Bangunkerto	Turi	7^O 38’ 54.0”	110^O 21’ 35.1”
7	Beneran	Purwobinangun	Pakem	7^O 39’ 14.5”	110^O 23’ 25.0”
8	Cemoroharjo	Candibinangun	Pakem	7^O 38’ 40.7”	110^O 24’ 17.9”
9	Jetisan	Hargobinangun	Pakem	7^O 38’ 03.2”	110^O 25’ 31.9”
10	Banteng/Sidorejo	Hargobinangun	Pakem	7^O 36’ 58.3”	110^O 25’ 34.4”
11	Tanen	Hargobinangun	Pakem	7^O 37’ 35.9”	110^O 25’ 10.7”
12	Boyong	Hargobinangun	Pakem	7^O 37’ 59.6”	110^O 25’ 11.1”
13	Nawung	Gayamharjo	Prambanan	7^O 47’ 52.1”	110^O 31’ 56.4”
14	Wukirharjo	Wukirharjo	Prambanan	7^O 49’ 07.7”	110^O 31’ 14.2”
15	Watuadek	Watuadek	Berbah	7^O 48’ 30.3”	110^O 27’ 43.5”
16	Klangkapan	Margoluwih	Seyegan	7^O 44’ 57.4”	110^O 17’ 36.4”
17	Tegalrejo	Margorejo	Tempel	7^O 39’ 04.3”	110^O 20’ 21.3”
18	Nglebeng	Margorejo	Tempel	7^O 39’ 19.2”	110^O 20’ 03.5”
19	Minggir	Minggir	Minggir	7^O 43’ 25.6”	110^O 14’ 11.5”
20	Bodan	Sendangsari	Minggir	7^O 42’ 55.3”	110^O 15’ 19.2”
21	Jl Ring road Utara	Kentungan	Sawitsari	7^O 45’ 29.0”	110^O 23’ 10.9”

Table 14.1.2 List of Survey Points (VES Yogyakarta 4points)

No	DUSUN	DESA	KECAMATAN	Latitude (S)	Longitude(E)
1	Jl Cantel	Miliran	Miliran	7^O 47’ 53.7”	110^O 23’ 14.7”
2	Jl Mungur	Gondokusuman	Gondokusuman	7^O 47’ 13.2”	110^O 23’ 7.1”
3	PDAM Kota Yogya	Jetis	Jetis	7^O 46’ 40.9”	110^O 21’ 58.3”
4	Kricak lor	Kricak	Kricak	7^O 46’ 09.7”	110^O 21’ 22.4”

Table 14.1.3 List of Survey Points (VES Bantul PDAM 20points)

No	DUSUN	DESA	KECAMATAN	Latitude (S)	Longitude(E)
1	Kamijoro	Kamijoro	Pajangan	7^{O} 52’ 52.8”	110^{O} 16’ 12.9”
2	Bejikulon	Sendangsari	Pajangan	7^{O} 52’ 26.0”	110^{O} 17’ 35.8”
3	Bejiwetan	Sendangsari	Pajangan	7^{O} 52’ 43.6”	110^{O} 17’ 01.1”
4	Perum Guwosari	Guwosari	Pajangan	7^{O} 51’ 23.2”	110^{O} 18’ 35.8”
5	Watugeduk	Guwosari	Pajangan	7^{O} 51’ 43.6”	110^{O} 18’ 25.5”
6	Bandengan	Bantul	Bantul	7^{O} 53’ 18.3”	110^{O} 20’ 01.8”
7	Jetisglondong	Panggungharjo	Sewon	7^{O} 50’ 58.9”	110^{O} 21’ 33.0”
8	Jl Imogiri Barat	Panggungharjo	Sewon	7^{O} 50’ 42.2”	110^{O} 22’ 28.4”
9	Bintaranwetan	Jl Wonosari km 12	Piyungan	7^{O} 49’ 42.9”	110^{O} 27’ 31.9”
10	Jombor	Srimulyo	Piyungan	7^{O} 50’ 41.5”	110^{O} 27’ 58.9”
11	Prayan	Srimulyo	Piyungan	7^{O} 50’ 52.9”	110^{O} 27’ 39.9”
12	Karangploso	Sitimulyo	Piyungan	7^{O} 50’ 26.9”	110^{O} 26’ 39.0”
13	Sampaan	Sitimulyo	Piyungan	7^{O} 50’ 03.3”	110^{O} 26’ 16.7”
14	Terong	Kebokuning	Dlingo	7^{O} 52’ 55.7”	110^{O} 27’ 07.8”
15	SMP 1 Dlingo	Kapingan	Dlingo	7^{O} 54’ 22.6”	110^{O} 28’ 10.6”
16	Dlingo	Dlingo	Dlingo	7^{O} 56’ 00.3”	110^{O} 27’ 55.6”
17	Imogiri	Imogiri	Imogiri	7^{O} 55’ 24.2”	110^{O} 23’ 22.9”
18	SPN(Sekolah Polisi)	Selopamioro	Imogiri	7^{O} 57’ 34.0”	110^{O} 25’ 08.8”
19	Becari	Seloharjo	Imogiri	7^{O} 57’ 39.9”	110^{O} 21’ 25.1”
20	Wonodoro	Mulyodadi	Bambanglipuro	7^{O} 56’ 55.3”	110^{O} 19’ 23.4”

Table 14.1.4 List of Survey Points (VES Bantul PU 15points)

No	DUSUN	DESA	KECAMATAN	Latitude (S)	Longitude(E)
1	Ciren	Triharjo	Pandak	7^{O} 55’ 04.7”	110^{O} 17’ 45.7”
2	Pantai Kuwaru	Poncosari	Srandakan	7^{O} 59’ 15.6”	110^{O} 13’ 39.8”
3	Grogo;	Parangtritis	Kretek	8^{O} 0’ 16.5”	110^{O} 19’ 01.1”
4	Soka	Seloharjo	Pundong	7^{O} 58 37.6”	110^{O} 20’ 34.3”
5	Karangasem	Wukirsari	Imogiri	7^{O} 54’ 19.2”	110^{O} 25’ 03.5”
6	Srumbung	Segoroyoso	Pleret	7^{O} 53’ 48.4”	110^{O} 24’ 03.6”
7	Purworejo	Wonolelo	Pleret	7^{O} 53’ 18.6”	110^{O} 26’ 13.0”
8	Kaligatuk	Srimulyo	Piyungan	7^{O} 51’ 16.8”	110^{O} 27’ 13.6”
9	Terong	Dlingo	Dlingo	7^{O} 53’ 16.1”	110^{O} 27’ 17.6”
10	Temuwuh	Tekik	Dlingo	7^{O} 55’ 10.0”	110^{O} 28’ 08.7”
11	Tangkil-Muntuk	Mangunan	Dlingo	7^{O} 54’ 31.4”	110^{O} 26’ 26.5”
12	Mangunan	Mangunan	Dlingo	7^{O} 55’ 53.0”	110^{O} 25’ 24.1”
13	Bangen	Bangunjowo	Kasihan	7^{O} 51’ 20.5”	110^{O} 18’ 04.4”
14	Serut	Guwosari	Pajangan	7^{O} 51’ 53.9”	110^{O} 17’ 36.7”
15	Metes	Argorejo	Sedayu	7^{O} 49’ 49.5”	110^{O} 16’ 25.6”

Table 14.1.5 List of Survey Points (2D Sleman 20points)

No	DUSUN	DESA	KECAMATAN	Latitude (S)*	Longitude(E)*	Azimuth
1	Kadisono	Margorejo	Tempel	7^{O} 39’ 40.7”	110^{O} 19’ 59.8”	N23E
2	Lumbungrejo	Margorejo	Tempel	7^{O} 39’ 23.4”	110^{O} 20’ 03.1”	N123E
3	Ledoknongko	Bangunkerto	Tempel	7^{O} 38’ 23.6	110^{O} 21’ 37.4”	N80E
4	Jurugan	Bangunkerto	Turi	7^{O} 39’ 24.8”	110^{O} 20’ 53.3”	N300E
5	Kawedan	Bangunkerto	Turi	7^{O} 39’ 57.7”	110^{O} 21’ 17.0”	N295E
6	Klegen	Trimulyo	Sleman	7^{O} 38’ 38.7”	110^{O} 21’ 32.2”	N113E
7	Kembangarum	Donokerto	Turi	7^{O} 39’ 21.6”	110^{O} 22’ 28.7”	N210E
8	Wringin Kidul	Purwobinangun	Pakem	7^{O} 38’ 45.7”	110^{O} 23’ 51.5”	N15E
9	Pulowatu	Purwobinangun	Pakem	7^{O} 39’ 31.3”	110^{O} 23’ 44.0”	N280E
10	Mangunan	Candibinangun	Pakem	7^{O} 39’ 35.4”	110^{O} 24’ 14.8”	N105E
11	Klabangan Utara	Candibinangun	Pakem	7^{O} 39’ 46.6”	110^{O} 24’ 45.9”	N210E
12	Klabangan Selatan	Candibinangun	Pakem	7^{O} 39’ 56.7”	110^{O} 24’ 45.0”	N195E
13	Beji	Hargobinangun	Pakem	7^{O} 39’ 29.4”	110^{O} 24’ 46.1”	N275E
14	Duwetsari	Hargobinangun	Pakem	7^{O} 40’ 38.3”	110^{O} 25’ 26.6”	N105E
15	Klidon	Sukoharjo	Ngaglik	7^{O} 42’ 21.9”	110^{O} 25’ 53.2”	N270E
16	Wonorejo	Wedomartani	Ngemplak	7^{O} 43’ 11.5”	110^{O} 25’ 44.7”	N183E
17	Tegalrejo	Wedomartani	Ngemplak	7^{O} 43’ 40.2”	110^{O} 25’ 37.0”	N285E
18	Karangmojo	Wedomartani	Ngemplak	7^{O} 43’ 42.5”	110^{O} 25’ 05.8”	N295E
19	Kayen	Wedomartani	Ngempak	7^{O} 44’ 08.5”	110^{O} 25’ 15.7”	N100E
20	Pokoh	Wedomartani	Ngemplak	7^{O} 44’ 04.1”	110^{O} 25’ 46.2”	N210E

*)Center Point of Survey Line

(3) Results of the Geophysical Exploration

Figure 14.1.5 shows the result of VES survey in Batul, Figure 14.1.6 shows the result of 2D imaging survey in Sleman. These results are examples of existing aquifer.

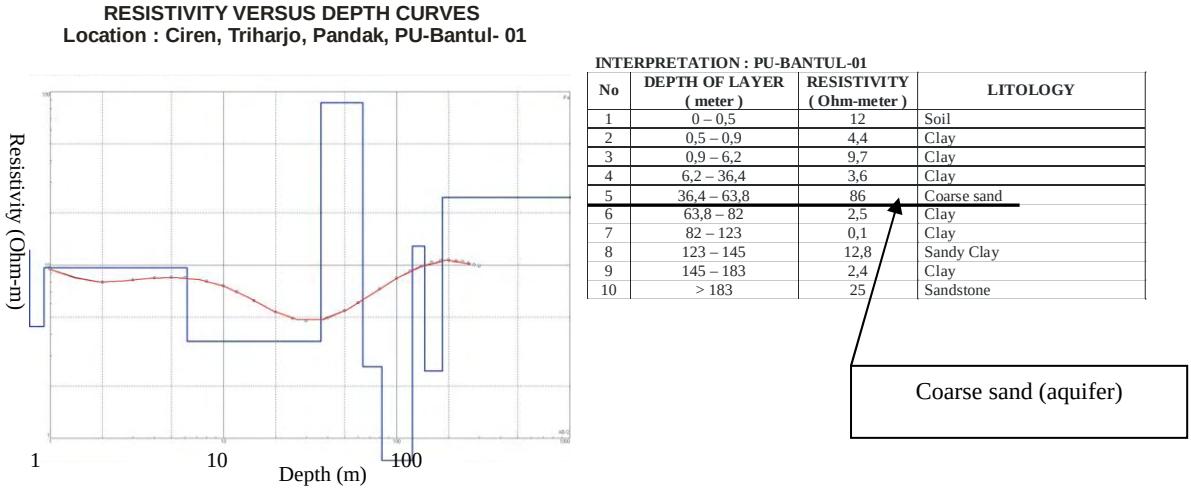
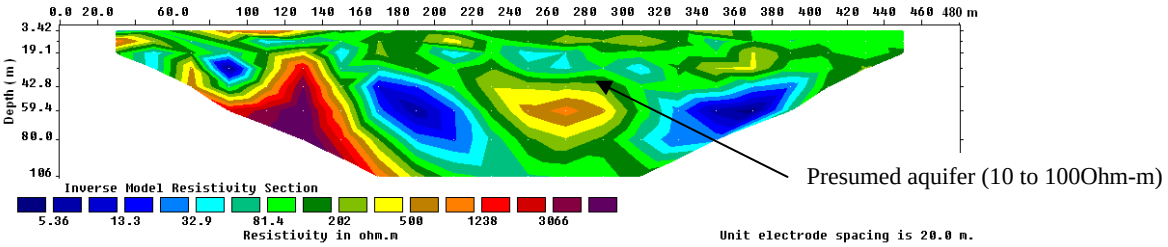


Figure 14.1.5 Result of VES Survey (Ciren, Triharjo, Pandak, Bantul)



Relationship between resistivity and geology

10 to 100 ohm-m (blue to green) : fine sand to coarse sand (volcanic sediment)= (**Aquifer**)

100 to 1000 ohm-m (green to red brown) : volcanic rocks (slightly weathered)
1000 ohm-m and more (red to violet) : volcanic rocks (fresh)

Figure 14.1.6 Result of 2D Imaging Survey (Kayen, Wedomartani, Ngemplak,Sleman)

According to previous studies, zone of 10 to 100 Ohm-m of resistivity value were presumed to be aquifer and especially zone of 30 to 100 Ohm -m have good groundwater for quality. In the 80 survey points, all points have this zone of 10 to 100 Ohm-m.

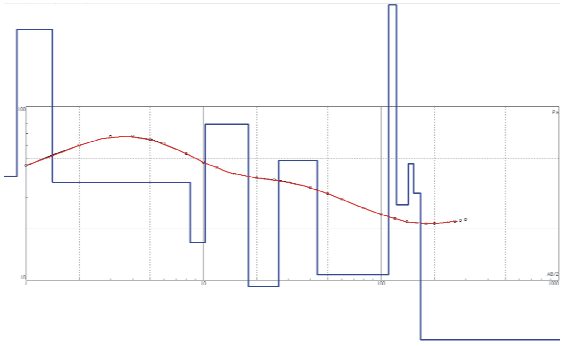
According to previous geological studies, quaternary deposits act as good aquifer are distributed in the plain fields in the study area. It seems to be high potential in the plain fields s in consideration of the result of geophysical exploration and geological conditions.

On the other hand, eastern area (Dlingo) and western area (Pajangan) of Bantul are mountainous areas and tertiary tuff and breccia those did not act as good aquifer are distributed in these mountainous areas so it seems to be difficult to develop groundwater in these areas.

Following figures show the results in the area distributed tertiary layers and quaternary layers. Although both areas have zones of 10 to 100 Ohm-m, these zones in the mountainous area distributed tertiary deposits have to be consider.

When developing groundwater in the tertiary area, detailed survey for geological condition and existing wells will be needed.

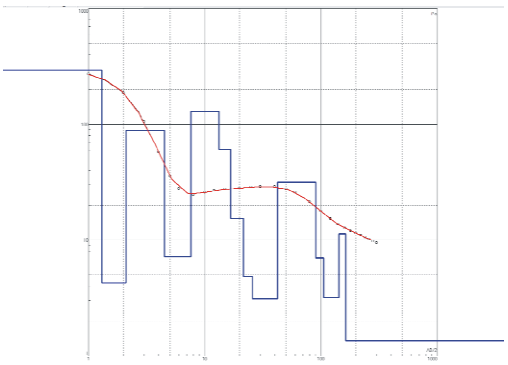
RESISTIVITY VERSUS DEPTH CURVES
Location : Terong, Kebokuning, Dlingo, PDAM-Bantul-14



層区分 No.	深度 (meter)	比抵抗値 (Ohm-meter)
1	0 – 0.8	40
2	0.8 – 1.4	37
3	1.4 – 10	16
4	10 – 18	79
5	18 – 26.5	9.2
6	26.5 – 44	49
7	44 110	11
8	110 – 122	495
9	122 – 142	27
10	142 – 152	47
11	152 – 167	32
12	> 167	5

Figure14.1.7 Result of Survey
(Tertiary Area)

RESISTIVITY VERSUS DEPTH CURVES
Location : Bandengan, Kota Bantul, PDAM-Bantul-06



層区分 No.	深度 (meter)	比抵抗値 (Ohm-meter)
1	0 – 1.3	293
2	1.3 – 2	4
3	2 – 4.5	88
4	4.5 – 7.6	7.2
5	7.6 – 13.2	129
6	13.2 – 16.7	61
7	16.7 – 21.6	15
8	1.6 – 25.8	4.8
9	25.8 – 42	3.2
10	42 – 90	31.2
11	90 – 105	7
12	105 – 142	3.2
13	142 – 163	11.3
14	> 163	1.5

Figure14.1.7 Result of Survey
(Quaternary Area)

**.* : zone of 10 to 100 Ohm-m

Figure 14.1.8 shows thicknesses of presumed aquifers (layers of 10 to 100 Ohm-meter) until 100 meter depth on the VES survey points. According to the figure, thicknesses of aquifers tend to be thicker in southern area roughly but fluctuations of thicknesses are not small.

Figure 14.1.9 shows the results of 2D Imaging survey in the study area. According to this figure, cross-sectional distributions of resistivity value in survey points are not regular and also regional characteristics of the results is not clear. Because past environment of sedimentation in the study area was complicated, geological layers in the study area are intricate. In order to select appropriate points for drilling in this complex surrounding, it is necessary to figure out the detailed hydrogeological condition of possible area of drilling. 2D imaging survey is suitable for the purpose.

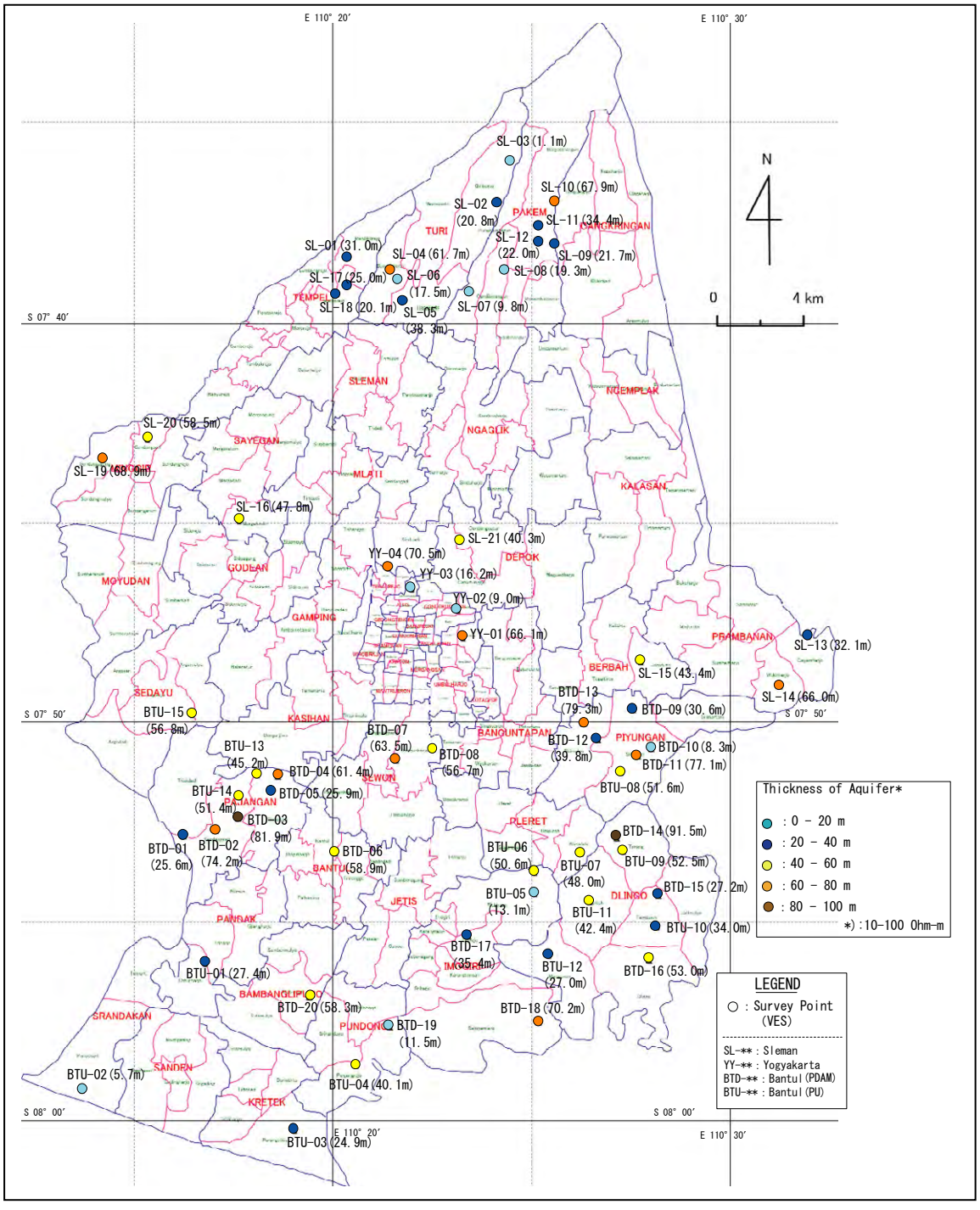


Figure 14.1.8 Thicknesses of Presumed Aquifers (in 100 meter depth)

Table 14.1.6 shows the average thicknesses of aquifers in each district.

Table 14.1.6 Average Thicknesses of Presumed Aquifers* in Each District

District	Number of Samples	Average thickness of Presumed Aquifer(meter)
Sleman	21	35.6
Yogyakarta	35	40.5
Bantul	4	45.7

**: layers those have 10 to 100 Ohm-meter resistivity value untily 100meter depth*

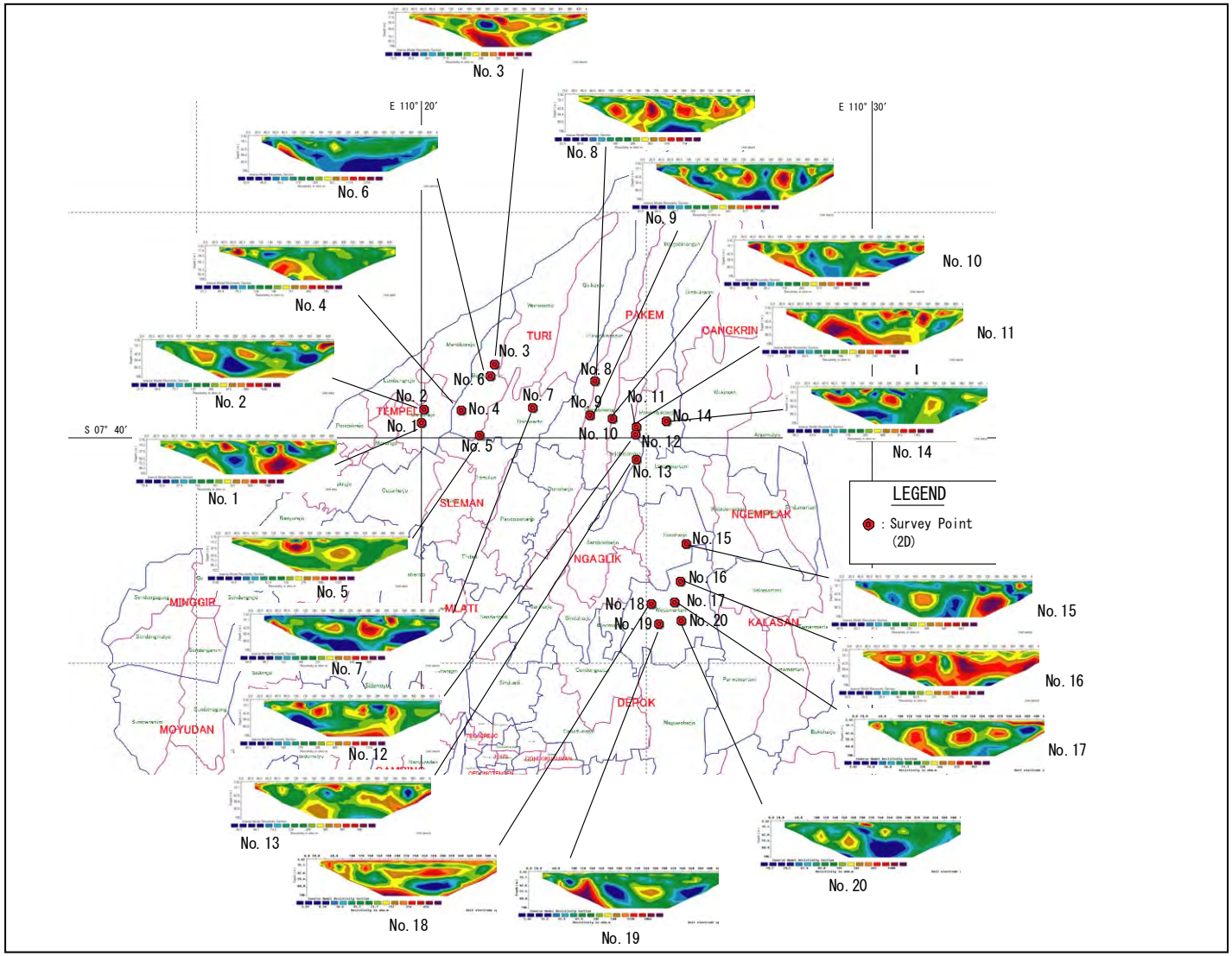


Figure 14.1.9 Results of 2D Imaging Survey

14.2 Potential Water Resources

14.2.1 Evaluation of Groundwater Balance

In order to estimate the potential groundwater resources, metrological and hydrological data were collected and analyzed.

(1) Meteorological Data and Hydrological Data

1) Precipitation

Table 14.2.1 shows monthly rainfall data those have been observed at Beran located roughly in center of the study area. According to the table, the annual rainfall ranges from around 1474 mm to 3573 mm. The maximum annual rainfall (3573 mm) was recorded in 1998 and the minimum is 1474 mm in 1997. The average of annual rainfall is 2602 mm.

Table 14.2.1 Monthly Rainfall Observed at Beran Station (1978-2005)

(S07° 43′ 50″, E110° 21′ 29″) unit : mm

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1978	353	122	563	157	145	328	229	373	161	151	214	526	3322
1979	565	201	539	431	314	61	9	13	51	67	111	486	2848
1980	533	379	245	381	62	3	2	143	7	165	490	325	2735
1981	249	459	602	209	395	190	112	0	68	102	623	200	3209
1982	487	412	129	188	0	0	0	0	0	1	77	346	1640
1983	-	377	208	309	417	0	0	0	0	215	350	165	-
1984	427	426	237	254	184	77	20	41	304	231	298	590	3089
1985	355	373	499	262	140	273	29	70	12	47	275	291	2626
1986	415	268	556	283	26	194	31	11	113	147	506	231	2781
1987	607	499	252	21	52	22	3	1	1	1	192	671	2322
1988	376	360	288	70	218	55	1	16	8	380	287	214	2273
1989	354	343	370	197	123	333	210	64	5	166	384	387	2936
1990	365	266	331	182	117	42	49	109	3	77	209	627	2377
1991	470	593	199	402	15	8	0	0	0	1	271	223	2182
1992	521	368	345	346	188	17	24	162	135	273	331	210	2920
1993	389	186	478	391	144	96	0	2	0	6	438	489	2619
1994	445	497	653	236	82	0	0	0	0	39	101	250	2303
1995	606	539	380	198	77	215	72	0	4	182	729	300	3302
1996	281	264	194	170	47	20	1	15	0	329	488	357	2166
1997	321	456	98	100	120	0	6	0	0	1	93	279	1474
1998	243	659	371	263	95	317	258	33	67	620	321	326	3573
1999	396	355	434	334	214	44	57	1	6	229	265	382	2717
2000	378	443	361	354	103	66	26	2	3	0	174	147	2057
2001	375	341	629	164	128	199	11	0	2	396	631	157	3033
2002	477	703	293	257	125	0	4	0	0	0	261	400	2520
2003	426	433	348	117	97	16	0	0	15	-	-	-	-
2004	447.8	274.5	274.5	56.0	109.0	10.0	49.8	4.0	5.2	57.5	326.9	692.8	2308.0
2005	428.1	362.0	264.0	223.9	7.7	42.5	39.6	10.0	33.8	177.2	85.0	650.3	2324.1
Average	**418**	**391**	**362**	**234**	**134**	**94**	**44**	**38**	**36**	**150**	**316**	**367**	**2602**
Maximum	607	703	653	431	417	333	258	373	304	620	729	693	3573
Minimum	243	122	98	21	0	0	0	0	0	0	77	147	1474

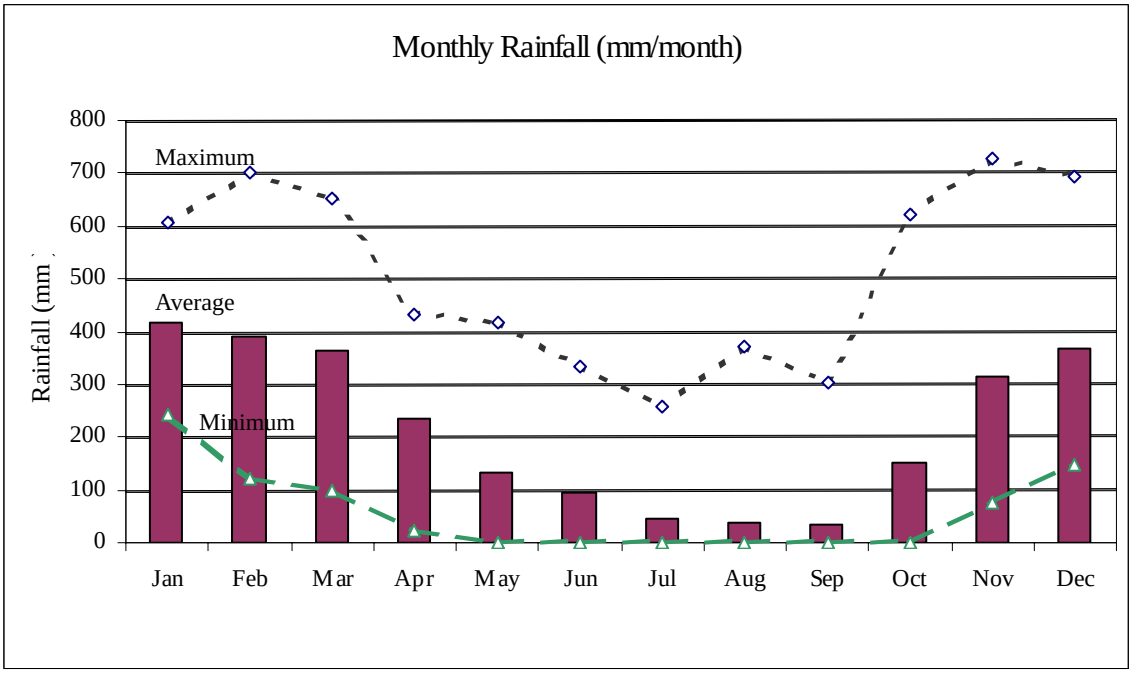
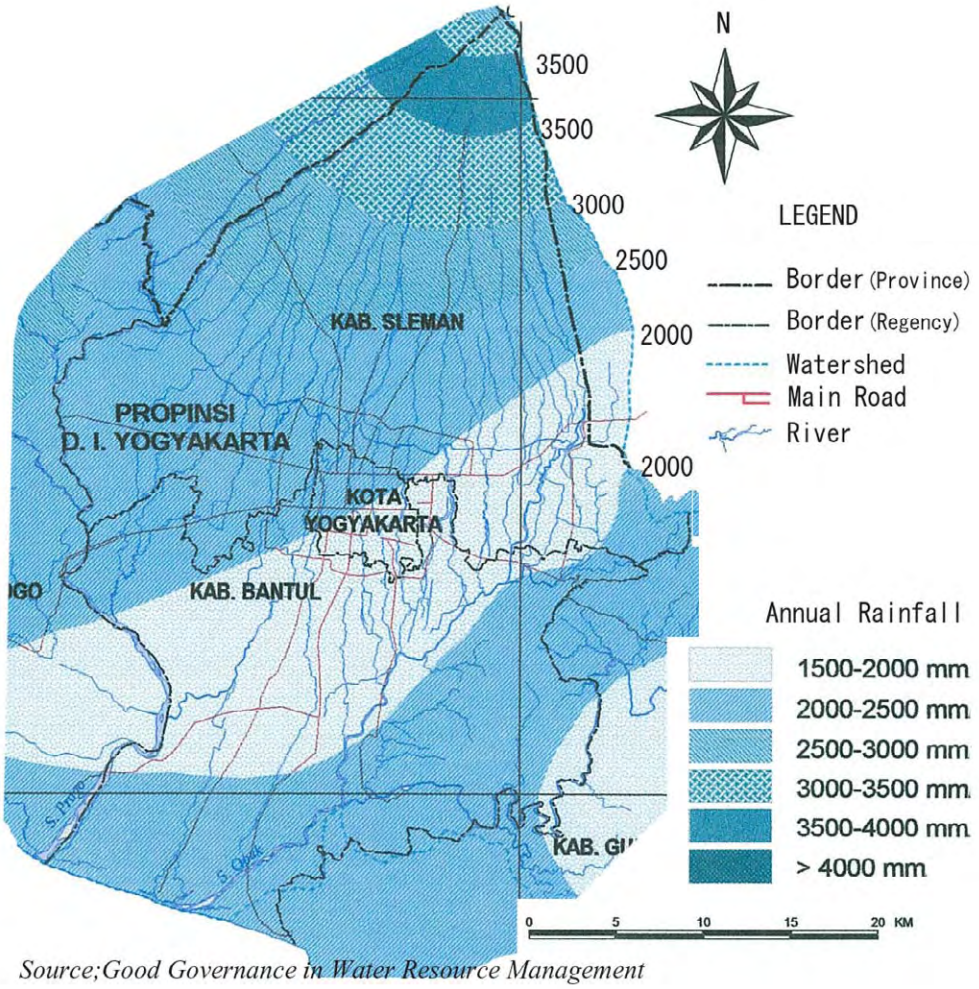


Figure 14.2.1 Monthly Rainfall at Beran

Figure 14.2.2 shows the distribution of annual rainfall in the study area that quoted from previous study.

Range of annual rainfall in the study area is from 1500mm to 4000mm. It may be possible that the figure indicates the northern high-altitude area may actually have more rainfall.



Source;Good Governance in Water Resource Management

Figure 14.2.2 Isohyet Map of the Study Area

2) Air Temperature

Following table shows monthly mean air temperature data those have been observed at Plambongan located roughly in center of the study area. This table also shows maximum and minimum temperature of each month.

The hottest months are March and April, and the coldest is July. Monthly mean temperatures in dry season (from May to September) tend to be lower than other season. The monthly mean temperature ranges between 25.3℃ and 26.0℃, and average from 1993-2005 is 25.9℃.

Table 14.2.2 Monthly Mean Air Temperature observed at Plambongan station (1993-2003)

（S07° 42′ 24″ , E110° 16′ 30″ ） unit : ℃

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1993	25.3	25.3	25.5	25.5	25.6	25.5	24.3	25.3	25.2	25.4	25.7	25.4	25.3
1994	25.2	25.3	26.7	25.7	24.9	24.1	22.5	-	24.7	26.4	26.4	25.6	-
1995	25.7	25.5	25.6	26.3	26.0	26.1	25.2	24.6	25.4	25.9	26.2	25.8	25.7
1996	25.6	-	25.9	25.6	26.1	25.7	25.6	25.0	25.8	25.9	25.9	26.7	-
1997	25.9	25.9	26.9	27.5	-	-	-	-	-	-	-	26.7	-
1998	27.7	27.0	27.1	27.6	27.6	27.7	27.8	27.7	-	-	-	-	-
1999	25.0	26.1	26.0	26.2	26.6	26.0	24.5	24.8	25.8	26.3	26.0	25.9	25.8
2000	25.8	26.0	26.1	26.3	26.7	25.8	25.5	24.7	25.9	25.8	25.7	26.1	25.9
2001	26.2	26.1	26.7	26.7	27.0	26.5	25.3	-	-	26.4	26.1	25.7	-
2002	26.3	26.2	26.6	26.5	26.6	25.7	25.2	24.6	25.1	26.2	26.4	26.4	26.0
2003	26.1	26.2	26.9	27.1	26.4	26.2	23.9	24.5	25.9	26.0	26.0	25.9	25.9
2004	-	-	-	-	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-	-	-	-	-
Average	**25.9**	**26.0**	**26.4**	**26.4**	**26.3**	**25.9**	**25.0**	**25.2**	**25.5**	**26.0**	**26.1**	**26.0**	**25.9**
Maximum	27.7	27.0	27.1	27.6	27.6	27.7	27.8	27.7	25.9	26.4	26.4	26.7	26.0
Minimum	25.0	25.3	25.5	25.5	24.9	24.1	22.5	24.5	24.7	25.4	25.7	25.4	25.3

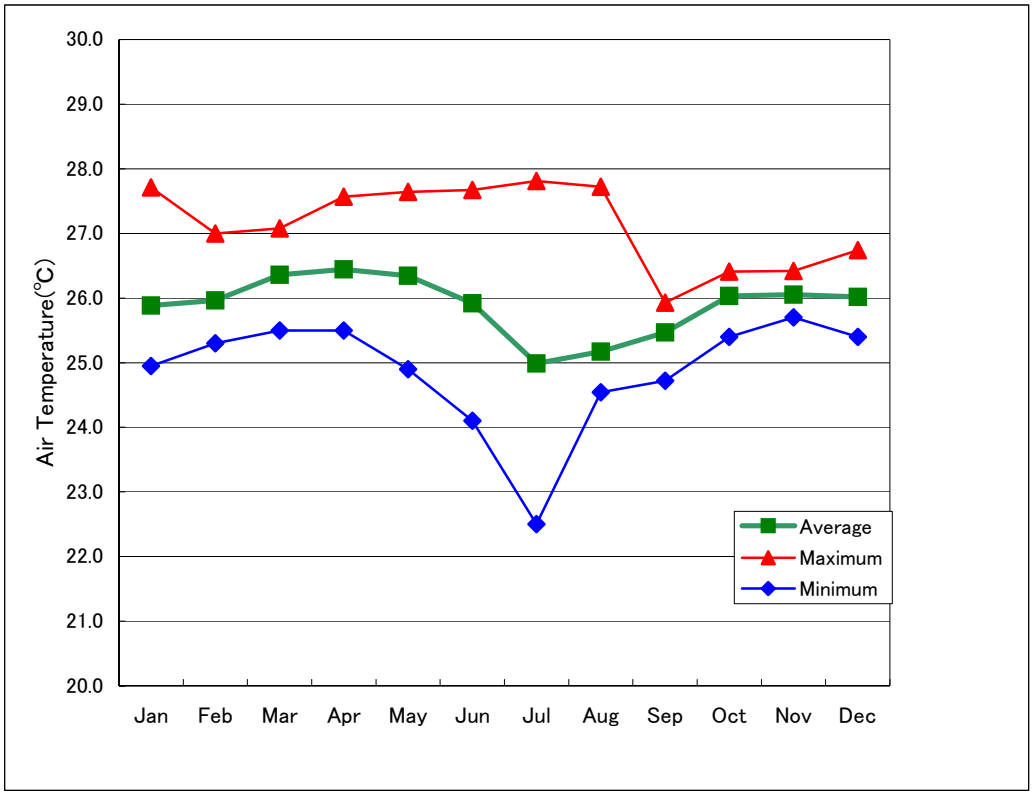


Figure 14.2.3 Monthly Mean Air Temperature (Average, Maximum and Minimum) at Plambongan (1993-2003)

3) Evapotranspiration

Using air temperature data at Plambongan, values of monthly evapotranspiration were estimated by Thornthwaite method.

Following formula shows Monthly potential evapotranspiration will be able to estimate from monthly mean air temperature.

$$Et = 16\left(\frac{10T}{I}\right)^{a} \quad , \qquad I = \sum_{i=1}^{12}\left(\frac{Ti}{5}\right)^{1.514}$$

$$a = (492{,}390 + 17{,}920I - 77.1I^{2} + 0.6751I^{3}) \times 10^{-6}$$

where, Et : Potential Evapotranspiration (mm/month)
T : Monthly Mean Air Temperature (℃)

Table 14.2.3 Monthly Evapotranspiration (Estimated by Thornthwaite Method)

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	Average/ Total
Monthly Mean Temparature ℃	**25.9**	**26.0**	**26.4**	**26.4**	**26.3**	**25.9**	**25.0**	**25.2**	**25.5**	**26.0**	**26.1**	**26.0**	**25.9**
*1Potential Evapotranspiration mm	132.3	120.0	138.4	132.0	132.8	120.5	110.3	114.3	116.8	133.7	131.5	136.0	1,518.6
*2Actual Evapotranspiration mm	92.6	84.0	96.9	92.4	93.0	84.3	77.2	80.0	81.7	93.6	92.1	95.2	1,063.0

**1): collected for day length depends on latitude of the station*
**2): set as 70% of Potential Evapotranspiration*

Following table shows the previous estimation result of evapotranspiration by using Penman method. This estimation is from EU's study, Greater Yogyakarta Groundwater Resources Study in 1984.

Table 14.2.4 Monthly Evapotranspiration from Previous Study (Estimated by Penman Method)

unit : mm

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	Total
North*	92	92	97	90	70	56	57	59	63	68	71	83	898
Central*	132	127	134	124	105	91	86	82	88	94	101	125	1,289
South*	129	123	131	121	103	87	86	89	95	103	103	120	1,290

Source; Greater Yogyakarta Groundwater Resources Study
**): North: Area above paddy field zone (North of Sleman Regency)*
South: Area below Mataram Canal (Mainly Bantul Regency)
Central: Area between the North and the South (Mainly South of Sleman and Yogyakarta Municipality)

The study area ranges from 0 meter to 2900 meter altitude, so evapotranspiration in the study

area should be different by location. According to above tables, data of annual evapotranspiration in the Study Area are ranging from 900 mm to 1300 mm.

4) Infiltration Rate

Infiltration rates were estimated in previous studies and were shown below table.

Table 14.2.5 Infiltration Rates from Previous Studies

Study	Infiltration Rate
Greater Yogyakarta Groundwater Resources Study	0.85～0.90
Good Governance in Water Resource Management	0.90

5) Groundwater Recharge

Groundwater recharge was estimated by using following hydrological water balance formula.

$$GWi=(P-E)\times I+\Delta S$$

Where, Gwi: Groundwater Recharge
P: Precipitation, Rainfall
E: Evapotranspiration
I: Infiltration Rate
ΔS: Change of Groundwater Storage (set as 0 throughout the year)

As mentioned above, annual Precipitation (P) is 2,602mm/year, estimated evapotranspiration (E) is 1,063mm/year, estimated infiltration rate (I) is 0.90, and groundwater recharge (Gwi) is 1385.1mm/year, based on the following previous researches.

- Greater Yogyakarta Groundwater Resources Study (Vol.2 Hydrology), Sir M Macdonald & Partners in association with Binnie & Partners Hunting Technical Services Ltd., Under assignment by Overseas Development Administration, London, December 1984
- Good Governance in Water Resource Management (GGWRM), BUKU II Laporan Perumusan Masalah Untuk Penyusunan, (Problem Formulation for the Development of) Basin Water Resources Management Plan (BWRMP) SWS POO, European Union, PPSDA Propinsi,DIY / Dinas PSDA Propinsi, Jawa Tengah, March 2005

Finally multiply the extent of the study area 1000km^2 by 1385 mm of Gwi, so total amount of groundwater recharge of the study equals **1.385 billion m^3/year.**

In the study area, several studies for water resources had been conducted. Following table shows the summary of results of previous studies. According to these results, the total amount of groundwater recharge in the study area range from **1.0 billion m^3/year (=32,000L/s)** to **2.1 billion m^3/year (=67,000L/s)**.

It seems that groundwater recharge in the study area ranges from 1.0 to 2.0 billion m^3/year approximately.

Table14.2.6 Summary of Results of Previous Studies in the Study Area

Study	Organization	Year	Groundwater Recharge (billion m^3/y)	Groundwater Storage (billion m^3)	Memo
Greater Yogyakarta Groundwater Resources Study	Overseas Development Administration (UK) / Sir M MacDonald & Partners	1984	1.0 (=32,000L/s)	_	
Evaluasi Potensi Air Bawah Tanah di Zona Akuifer Merapi (Evaluation of Potential of MerapiAquifer)	Fakultas Teknik, Universitas Gadjah Mada	2001	(1.0) quoted value from the above study	5.0	
Good Governance in Water Resource Management	European Union / PPSDA Propinsi,DIY / Dinas PSDA Propinsi, Jawa Tengah	2005	2.1*1 (=67,000L/s)	_	
Penyelidikan Potensi Airtanah (Study of Groundwater Potential in Banlul)	Dinas PERINDAGKOP, DIY	2006	0.34 (=11,000L/s) (Bantul only)	10.2 (Bantul only)	Bantul only
Kajian Potensi dan Pemanfaatan Sumber Daya Air (Study of Water Resources Potential and Water Uses in Sleman)	PU Sleman	2006	_	8.0*2 (Sleman only)	Sleman only

**1) value estimated from the survey result*

**2) revised value (the report shows 11.6 billion m^3, but the calculation process has a error)*

6) Groundwater Consumption

Following table shows estimated water consumption in the study area from previous studies.

Table 14.2.7 Water Consumption by Use (m^3/year)

Use	Sleman	Bantul	Yogyakarta	Total
Tap Water (PDAM)*1	5,612,405	3,385,821	18,290,918	27,289,144
Industrial Water*2	2,506,652	5,393,670	2,535,502	10,435,824

**1) actual value in 2005 Source;PDAM*

**2) estimated value in 2002 Source;Good Governance in Water Resource Management*

In addition to above uses, much water has been used for irrigation but the irrigation water has been taking from surface water, river mainly.

Total of these consumptions is 0.04 billion m^3/year approximately so there is still enough potential groundwater resources in the study area.

CHAPTER 15

ISSUES TO BE CONSIDERED IN MASTER PLAN

Chapter 15 ISSUES TO BE CONSIDERED IN MASTER PLAN

15.1 General

Preparation of a Master Plan was originally included in objectives of the Study. However, the Study is decided to be regrettably terminated after investigations of existing conditions/situations since authorized detailed information concerning DBOT Bulk Water Supply Project were not provided by Indonesian side as described in Chapter 1.

In this chapter, issues to be considered in Master Plan, which is hoped to be prepared in future, are described based on results of various kinds of investigations and analysis on existing conditions/situations.

15.2 Issues on Legislative and Institutional Aspects

15.2.1 Legislative Issues

Indonesia has Water Resource Law (UU 7/2004) which is one of most advanced water laws in Asia in terms of three superior points. Those are: (i) river-basin management system is institutionalized; (ii) transparent water charging mechanism is introduced; and (iii) water rights are clearly defined. To implement the water law forcefully and effectively a number of regulations are needed. These regulations have not been established fully to date. Among them, the following regulations should be enacted in our planning context.

To begin with, the government regulations on management and control of surface water and groundwater should be enacted. The management and control of the water sources is one of most important legal matters in order to plan and implement sustainable water resource management plans. However, the rules and regulations on management and development of those waters have not been issued by the Central Government though these are clearly specified in Articles 12, 36 and 37 of the Water Law 7/2004. Issue of this regulation is highly awaited.

Second, the Regulations on Drinking Water Supply System (PP 16/2005) calls for a number of ministerial regulations. Out of these, regulations on BPPSPAM, tariff setting and financial restructuring for PDAMs have been enacted. But, specific guidelines for SPAM management, operation &maintenance, and monitoring & evaluation have not been published.

Last but not the least, PP16/2005 stipulates roles and functions of the three-tire governments (central, province and district/PDAM). Therefore the institutional responsibility of entities

concerned looks like clearly defined for three main functions of (i) policy making, (ii) regulation, and (iii) operation. Out of these the regulatory function needs to be further clarified. There is a mention of Supervisory Board for SPAM management at Province level in PP 16/2005, but detailed rules of the Board have not been published.

15.2.2 Institutional Issues

The DIY Provincial Government is going to promote regional integration of water supply operation over wider areas under the initiative of Greater Yogyakarta (Kartamatul). Municipal water services are provided by city or regency basis in Indonesia like in Japan. It is controversial that area-wide integration beyond regency level is legally permissible or not. However it is highly commended that DIY Province is exploring such integration aiming at better water service and more efficient operation in wide-area covering three PDAM operations. Should the DIY Province Government sincerely pursue the possibility of such integration, the issues and options on this regional integration should be considered in the master plan. Main discussion points are as follows.

Chapter 7 reveals each PDAM has its own specific needs different from those of other PDAMs. For example, regarding water resource availability Kota and Bantul need water from outside, but Sleman is able to manage own demand from its abundant spring water source. The water service coverage is high and saturated for Kota, but low for Sleman and Bantul. Financially, Kota attains the full-cost recovery by tariff revenue while Sleman is unacceptable and Bantul is barely acceptable. The three PDAMs are facing common problems, including high water losses and overstaffing.

The regional integration must bring the win-win solution for all the three PDAMs: (i) Kota accesses to sound water sources; (ii) Sleman improves financial status and service coverage; and (iii) Bantul accesses to sound water sources as well as improves financial and service coverage. Operational integration must eventually improve water losses and customer relations for all PDAMs. The integration must also improve the service quality and tariff system to the satisfaction of the customers as a whole.

There are a number of possible types of integration. Indonesia has not experienced area-wide integration in water services. Therefore, we refer to experiences in Japan where regional integration of water services is becoming popular in various local governments. We believe Japan’s experiences be useful for Indonesia. In Japan there are three models of management integration by wide-area operation.

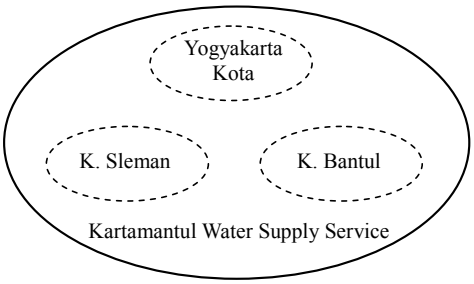
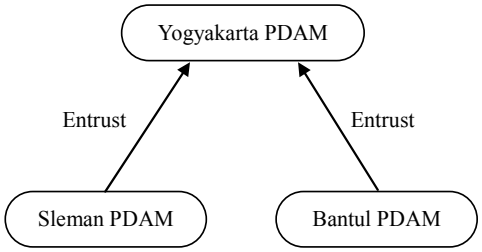
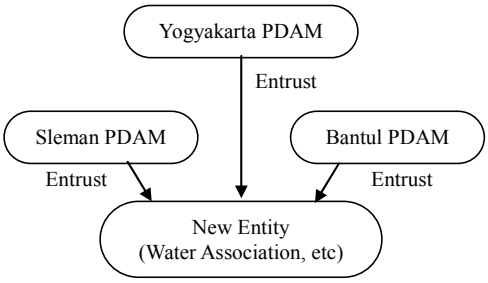
Table 15.2.1 describes outlines of three models likely fit into three PDAMs which are adapted to the local conditions from similar experimental cases adopted in Japan.

- Model 1: The 3 PDAMs are merged and integrated into one water company.
- Model 2: The financially weak PDAMs (Sleman and Bantul) entrust operation to the financially strong Kota and Kota operates the wider area unified.
- Model 3: An independent water association will be created and each PDAM will entrust operation to this new entity.

The main issues to be addressed in the master plan include: (i) methodology of management integration for model 1; (ii) basic rules for entrust, including scope of contract-out and types of contracts, etc for models 2 and 3.

Then in the master plan, the parties concerned (DIY province, three regional governments, three PDAM managements, etc) are recommended to discuss their likes/dislike, pros/cons and advantages/disadvantages of proposed options to see such regional integration is possible and if it is possible which option is the most favorable. Legal arrangement needed to implement the selected option will be worked out as well.

Table 15.2.1 Models of Management Integration by Wider Area Operation

Model 1 • The 3 PDAMs are merged and integrated into one water company. • Provision of xisting water services are abolished. • Existing physical systems are operated separately (as per PDAM) not unified.	
Model 2 • Sleman and Banbtul entrust operation to the financially strong Kota and Kota operates the wider area in unified system.	
Model 3 • An independent water association is created and each PDAM entrusts its operation to this new entity.	

(Source) JICA Study Team

15.3 Issues on Water Supply Facility Planning

15.3.1 Water Resources

According to the estimation of groundwater potential in Chapter 14, there is still high potential of groundwater so it is possible to develop groundwater resources for water supply. Issues to be considered concerning water resources in future water supply facility planning are listed below.

(1) Groundwater Resources in Northern area of Sleman

The northern high-altitude area (mainly Sleman Regency) of the study area has more rainfall than the lower part of the study area and has less evapotranspiration than the other part, so groundwater recharge in the northern area must be much more than the other part. This area has also advantage of distribution of water to lower area because of high altitude. Further groundwater development in Sleman Regency should be carefully studied in the Master Plan.

(2) Comparison of DBOT Bulk Water Supply Project and Development of Water Sources in Yogyakarta Municipality and Bantul Regency

In order to consider water supply planning in Yogyakarta Municipality and Bantul Regency, progress of DBOT Bulk Water Supply Project should be carfully monitored. If there is no prospect for resuming of the DBOT project, it is needed to consider alternative water sources such as groundwater development.

(3) Conserving Groundwater Resources for Sustainable Use

There is high potential of groundwater in the study area, but unrestricted consumption of groundwater lead the depletion of water resources in the study area. For sustainable use of groundwater, it must be needed to conserve groundwater resources in aspects of quantity and quality. Concrete plans to conserve groundwater resources are follows.

- Development of registration system for pumping
- Development of monitoring system for pumping and water level
- Installation of limitation of maximum quantity of pumping for each well or region
- Upgrading sewage system especially in urban area

(4) Comparison of Shall Well with Deep Well as Source of Water Supply

PDAM Sleman is trying transition from deep well to shallow well as water sources because water from deep well has high content of iron and manganese. Water of shallow well has less iron and manganese than it of deep well but is susceptible to pollution from ground surface. It

has to be more careful about pollution when using shallow well as water sources than using deep well.

15.3.2 PDAM Water Supply System

(1) Water Demand and Supply Capacity

According to the results of future water demand projection, existing water supply capacity is not sufficient for all cases of demand projections (Case 1 to 4) as discussed in Chapter 13.

Shortages of water supply capacity (gap between total future water demand and existing total supply capacity of three PDAMs) for respective cases of water demand projections are summarized in Table 15.3.1.

Table 15.3.1 Shortage of Water Supply Capacity in 2020

Case of Water Demand Projection	Shortage of Water Supply Capacity in 2020 (l/sec)
Case 1	4,330
Case 2	2,300
Case 3	1,690
Case 4	1,280

Even though for Case 4 which shows the least future water demand, shortage of supply capacity will be 1,280 l/sec in year 2020. Taking account of existing water supply capacity, total of 3 PDAMs is 850 l/sec, significant magnitude of system expansion will be required to meet future water demand.

In order to decide magnitude of system expansion, target future water demand should be selected from four cases of future water demand shown above in the course of preparation of Master Plan. Feasibility, adequacy, and practicability of the planned project from various aspects such as technical, environmental, and financial should be confirmed very carefully in the Master Plan. In addition, appropriate phased planning with effective use of existing facilities and rehabilitation such as WTP or transmission/distribution pipelines should be considered.

Since water supply capacity should be expanded more than double of existing capacity even for the Case 4, stage-wise expansion plan should be studied in the Master Plan to avoid heavy physical and financial impacts to the PDAMs.

It should be noted that a rate of future water demand increase in Yogyakarta Municipality is much lower than the ones of Sleman and Bantul Regencies. Expansion of supply capacity should be considered especially for these two regencies.

(2) Effective Water Resource Allocation to Water Supply Facilities

In the Master Plan, water supply system development should be studied conforming to potential and availability of water resources of respective areas. Topographical and geographical conditions of area are also significant factors which should be taken into account for preparation of the Master Plan.

From water sources to distribution reservoirs and from distribution reservoirs to customers, gravity flow system should be applied as much as possible to avoid unnecessary energy consumption. Figure 15.3.1 shows location of contour line of EL. 125 m. Mataram canal which will be the route of future clear water transmission line (planned as part of DBOT Bulk Water Supply Project) runs along with contour line of EL. 150 m toward Yogyakarta Municipality from the Progo River. Area lower than EL. 125 m may be supplied by the new system taking account of piping head loss and required residual pressure at customer taps.

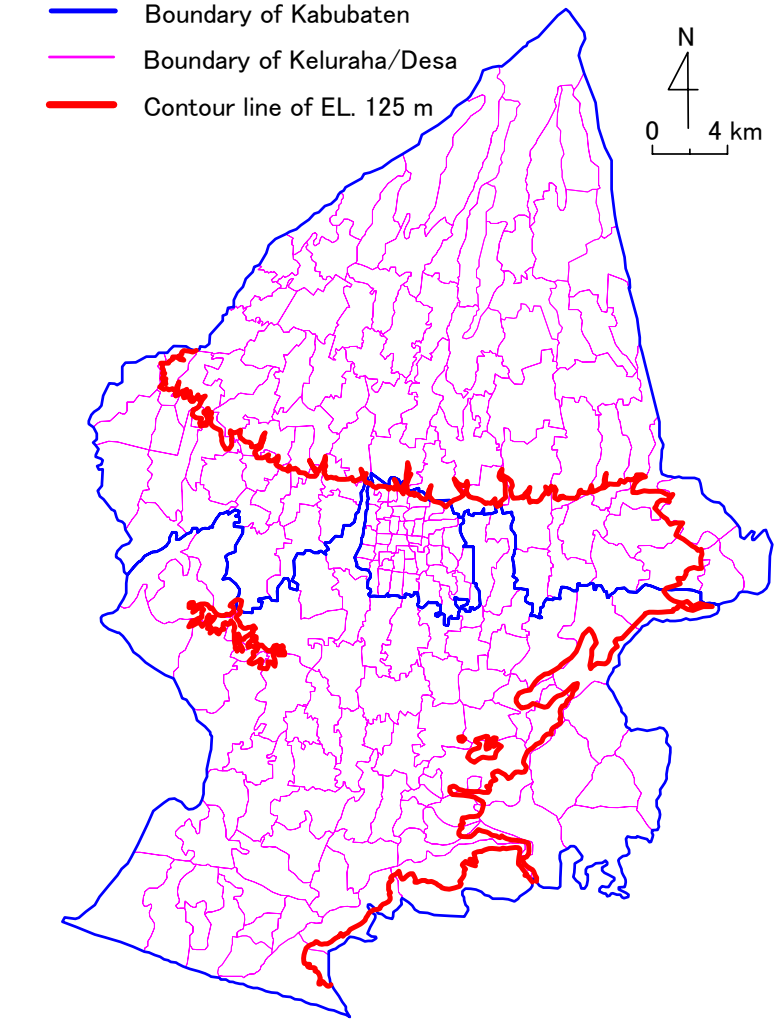


Figure 15.3.1 Contour Line of EL. 125 m in Study Area

Most of Sleman Regency, eastern part of Bantul and partially in western part of Bantul Regency are higher than EL. 125 m. Water sources for these higher area are recommended to be developed within these area instead of pumping from lower area to higher area. Specially for Sleman Regency, as described in previous section concerning potential groundwater source, there are rich groundwater sources and they should be adequately developed as water sources for water supply

in Sleman Regency.

For higher area in Bantul, such as Dling, groundwater development in these area or raw water transmission from the Oyo River will also be ones of alternatives which should be considered in the Master Plan.

For Yogyakarta Municipality and lower plain to the sea in Bantul Regency, not only planned bulk water supply but also groundwater developments in these areas should be considered and compared in the Master Plan. For these comparative studies, trend of water demand increase, implementation schedule (timing of development/implementation), level of operation and maintenance required, and financial situation should be taken into account.

(3) Application of Appropriate Treatment Process

According to the opinion of the PDAM Sleman, it would like to switch its water sources from deep wells to shallow wells since groundwater from the deep wells contains higher manganese/iron concentration than the shallow wells.

Comparison or selection of groundwater sources among deep or shallow wells should be carefully studied considering energy costs of pumps and treatment costs for removal of manganese/iron.

There are several existing aeration towers which assist oxidization of iron/manganese by contacting with air (cascade type aeration). These facilities are equipped with lift pumps and they consume energy. To save energy costs of the lift pumps and well pumps also, PDAM Sleman would like to switch its water sources from existing deep wells to shallow wells.

Under such situation, treatment process, removal of iron and manganese, should be examined as less energy consuming system such as bacteriological method. The most adequate treatment process should be selected considering technical appropriateness, required operation and maintenance level, and financial aspects.

(4) Transmission and Distribution System

1) Transmission Pipeline System

To apply gravity flow system as much as possible, location of water source and alignment of transmission pipeline from the water source should be carefully planned in the Master Plan. For instance in Sleman Regency, water source should be developed in higher area than target service area and dimensions of the transmission pipeline should be decided to accommodate day maximum water demand of the target service area by gravity flow.

2) Distribution Pipe Network System

According to the results of preliminary hydraulic analysis in sample areas, pressure distribution seems not adequate. It means that pipe size is not sufficient for which route requires larger size pipe and pipe size can be reduced where distribution pressure is too high.

Since water demand will not increase remarkably and many pipelines had already been installed in Yogyakarta Municipal area, the PDAM Yogyakarta should put its efforts on pipe replacement and rehabilitation of aged and deteriorated pipelines.

When the distribution system is planned in Master Plan, zoning system or district metering system should be considered so as to maintain consistency with NRW reduction plan. In addition, considering that there are some service area supplied by PDAM Yogyakarta in Sleman Regency, appropriate zoning and demarcation of service between PDAMs concerned should be thoroughly studied in future master plan.

3) Individual (House) Connections

Since many portion of leakage generally occurs on individual (house) connections, material of connections and quality of connection installation work should be improved. Standard design of connection should be studied in the Master Plan including recommendable specifications of suitable materials for connections.

(5) Monitoring/Measurement of Water Quantity

Monitoring water quantity is fundamental for water supply providers. Performance of water supply system could not be evaluated without accurate information of water quantity. Water quantity should be measured at,

- Water intake (raw water quantity),
- Water treatment plant (at respective treatment process),
- Outlet from treatment plant (treated water quantity),
- Inlet of distribution reservoir (buying water for the case of bulk water supply),
- Outlet of distribution reservoir (distributed water quantity),
- Inlet of respective water supply district (if district metering system is considered), and
- Customer water meter (water consumption).

Improvement of these metering facilities should be carefully planned in the Master Plan. In addition to the facility improvement, data (water quantity) corrected from each metering facility or water meter on house connection should be gathered at one place and they should be evaluated. The results from the evaluation will give valuable suggestion for reduction of NRW ratio and basic information of prioritization of pipe replacement planning.

It should be noted that water meters which measures water quantity should be calibrated and

customer water meter should be replaced periodically otherwise data of water quantity becomes not reliable. For this purpose, meter calibration system should be clearly defined in operation and maintenance manual, meter shop for meter calibration should be established, and legislative and budgetary arrangements for periodical water mete replacement should be discussed in the Master Plan.

(6) Implementation of Effective NRW Reduction Measures

According to the results of diagnosis of existing condition, existing NRW level is more than 40 % in average for three PDAMs. To reduce NRW ratio, the most efforts should be put on leakage reduction for three PDAMs. In the Master Plan, strategic leak reduction approach should be studied.

Figure 15.3.2 shows example of strategic leak reduction approach. The first priority should be establishment of leak reduction team in PDAM organization which solely works for leak survey and repair.

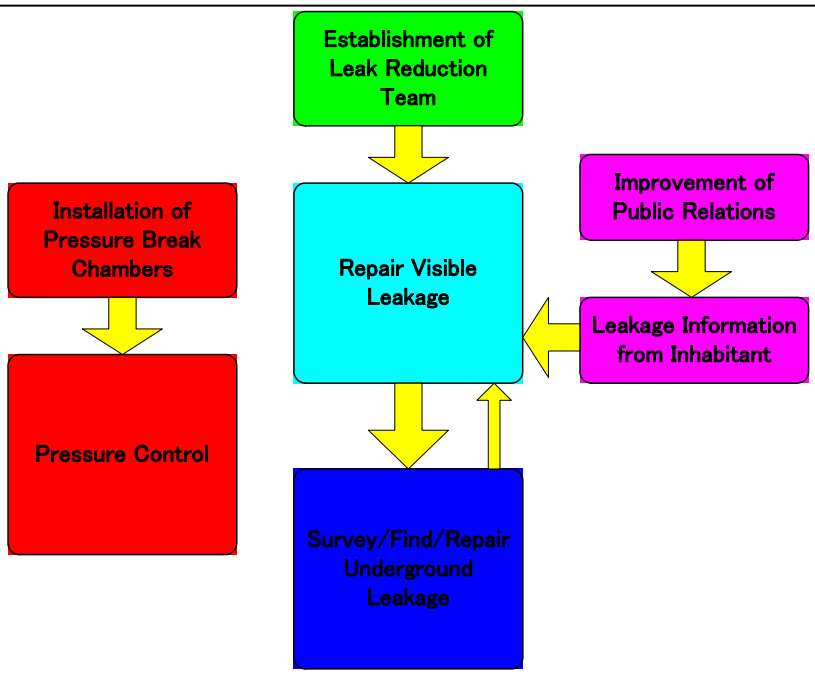


Figure 15.3.2 Strategic Leak Reduction Approach

Since the PDAM has not yet enough capacity to search underground leakage, above ground visible leakage should be repaired as the first action. Location of visible leakage will be found by survey (observation along pipeline route) by the leak reduction team and by information from inhabitant.

To implement such survey along the pipeline route, pipeline drawings are indispensable information. Unfortunately, detail and accurate drawings of pipelines are not completely available in PDAMs. Effectiveness of the survey will be improved by provision of the drawings and they will be improved as part of the asset management which will be discussed in proceeding section.

Once the PDAM has enough capacity of leakage survey and equipment, the leak reduction team will commence underground leakage survey. In the Master Plan, these capacity development of PDAM for leak reduction should also be discussed.

Specially in Sleman Regency, there are several pipelines which has very steep gradient. To avoid extreme high pressure, which may cause leakage, at downstream of such pipes, pressure break chambers should be adequately installed for pressure control.

In addition to leak survey and repair mentioned above, preventive measures for suppressing occurrence of leakage should also be considered in the Master Plan. The preventive measures will include,

- Selection of adequate pipe material conforming to situation/environment of the location,
- Improving quality of pipe installation work, and
- Improving quality of house connection installation work.

According to the experience in Japan, about 90 % of leak points were found on house connections. Therefore, improvement of quality of house connection installation work will contribute for suppressing occurrence of new leakage.

(7) Water Demand Management

Although it depends on selection of target future water demand cases which are described in Chapter 13, domestic per capita water demand should be reduced from existing level in several area for Cases 2 to 4. To have understanding of customers concerning water demand management, it is necessary to launch public relations campaign about water conscious life style and limited water resources.

Review of tariff structure will be also key measure for water demand management and measures and strategies of water demand management should be discussed in the Master Plan.

(8) Public Relations

Well understanding on water supply system by customers is one of the most important aspects for provider. Without maturing mutual confidence, customers' cooperation to or understanding of water supply system will not be anticipated. To have confidence from customers, providers should provide good services such as supplying water continuously with adequate pressure and with suitable quality for drinking. Public relation activities should be implemented to help maturing mutual confidence.

Customers sometimes complain about smell of tap water because of injected chlorine for disinfection. Customers do not aware of purpose of chlorine even the smell of chlorine is an

evidence of safe water. This kind of misunderstanding should be solved through adequate public relations.

15.3.3 Community Water Supply System

This section focuses on summary of current problems identified and special considerations for formulation of master plan in future.

(1) Visions for Future Development of Community Water Supply Systems

Conforming to the MDGs, National Action Plan advocates improvement of service ratio of safe drinking water up to 80% for urban area with 100 l/d per capita and 60% for rural area with 60 l/d per capita in its "National Level Target to 2015". In order to meet this target effectively and efficiently, new water supply development projects in future should be planned and implemented in comprehensive and systematic manner.

In fact, according to the interview with officials of regional PUs, candidates of new development projects for community water supply are picked up among requests from communities, giving first priority to the communities which are regarded as more critical than others by the local government responsible. In this way, there is only a short-term planning (within 1 to 2 years) for new development of community water supply systems based on the request of communities, without long-term view.

In order to formulate future development plan effectively and efficiently, it is necessary to have some sort of basic concept to direct right way for future development plan, such as, priority development area, transfer from community system to PDAM and vice versa.

Following aspects could be incorporated to a consideration of future development of community water supply:

- Poverty-prone area (refer to the following section)
- Remote area, where current service ratio (refer to Appendix 15.1 and Appendix 15.2) and possibility of future development by PDAM are quite low
- Isolated area, where water resource is potentially available
- Geographically isolated area (e.g., community developed in a top of hilly area, etc.)

(2) Poverty Distribution and Water Tariff

1) Poverty Distribution in the Study Area

The branch office in DIY of BPS (Biro Pusat Statistik: Central Bureau of Statistics) published the result of statistical survey concerning poverty situation in the DIY in 2006 (hereinafter referred to as "Poverty Statistics 2006".

This statistic survey is for the purpose of determination of eligibility of BLT (Buntuan Langsung Tunai: social welfare) recipients and decides its benefit amount according to recipients' poverty level (for criteria used to evaluate poverty level in the Poverty Statistics 2006, refer to Appendix 15.3). In this survey, those who are recognized as the social welfare recipients are further divided into 3 groups as "Somewhat Poor", "Poor" and "Very Poor", in consideration of their condition on food, clothing and shelter expenses and their geographical living conditions, by district (Kelurahan or Desa).

Based on the result of the above "Poverty Statistics 2006" shown in Appendix 15.4, poverty distribution map of the Study Area are prepared and it is presented in Appendix 15.5. As shown in the distribution map, percentages of those who are regarded as "Somewhat Poor", "Poor" or "Very Poor" are relatively high in the fringe area of urban district of Yogyakarta Municipality. Especially, areas which have geographically isolated villages tend to be relatively high percentage of poverty households (e.g., Prambanan, Cangkringan, Sleman, Minggir in Sleman Regency, and Pleret, Imogiri, Sedayu, Pandak, Sanden in Bantul Regency).

In order to contribute poverty reduction to meet MDGs and National Action Plan, it is regarded as one of the most effective measures to give first priority in new development of community water supply system to the areas where percentage of poverty is higher than the others.

2) Water Tariff

Water tariff and its structures (fixed or metered rate) for community water supply system are widely different from village to village. The average water charge by community water supply service is roughly calculated, on the basis that one household use 10 m^3 a month (60 lpcd x 5 persons x 30 days), based on available data obtained through interview survey (refer to Appendix 15.6).

According to the calculation result, the average water charge by community water service is approximately Rp. 8,000/month/HH. Under the same conditions, water charge by PDAM service is around Rp.12,500/month/HH according to Section 7.2.4 of this Technical Report. This comparison shows that water charge by community water supply is approximately 60 % of that of PDAM services, based on the data available.

Although more data are required for accurate comparison, the above trial calculations give suggestions that service by community water supply could give financial advantage to low-income families over the service by PDAM.

In addition, cost for operation and maintenance for community water supply systems in the

Study Area are fully covered by their own revenues, in principle. On the other hand, PDAMs of Bantul and Sleman cannot fully cover their operation and maintenance cost by their own revenue at present. Taking a principle of full-cost recovery into account, potential gap of water charges between by community water supply services and by PDAM's service would be wider than it is.

(3) Special Attentions for Formulation of Master Plan

1) For New Development

As discussed above, master plan should be formulated with due consideration of following aspects:

- Think primarily of poverty reduction in line with the upper level plans such as MDGs or National Action Plan
- Focus on priority area
- Appropriate phasing

2) For Future of Community Water Supply Service

Many community water supply systems in the Study Area tend to form one isolated system within their village. In some cases, two or more adjacent systems share same reservoir(s) or water source(s) to form one united system, such as AMDs in Prambanan in eastern Sleman or some areas in Bantul. In such area, water supply systems would be more complex or capacity of each facility would be bigger than that of small scale simple water supply systems. The more complex systems become and the bigger capacities of facilities become, villagers would have difficulties to deal with possible troubles for O&M by themselves without the assistance of specialists.

On the contrary, this is the case that the PDAM Sleman wishes to transfer some thinly-populated area in the northern part of Sleman, which is currently covered by the PDAM service, into a community supply service. Possibility of the transfer case from PDAM to community service should be considered as an opposite case to the case mentioned above.

Therefore, possibility of transfer from community water supply service to PDAM and vice versa should be discussed, with due consideration of the following viewpoints:

- Profitability (can this transfer case secure certain amount of customer to ensure profit?)
- Water tariff (can new water tariff meet affordability of customers after the transfer?)
- Quality of service (can this system maintain quality of service for customers?)

For discussion on transfer, future financial condition of PDAM should be taken into account as well as technical aspects such as operation and maintenance.

3) Capacity Development Strategy and Technical Support for Appropriate O&M

For proper master planning and its effective implementation, following issues should also be well-considered and incorporated into the master plan:

- Capacity development strategy for PU and WUO
- Formulation of steady system for technical support by PDAM

Above these issues are further discussed in the following Section 15.4.2

15.4 Issues on Operation and Maintenance Planning

15.4.1 General Issues

Water supply system in the Study Area is facing difficulties in maintaining its service quality because of the following situations or conditions:

- The existing water supply facilities in the Study Area are yet to meet its increasing demand brought by recent rapid population growth.
  - Due to development of surrounding area of Yogyakarta Municipality in recent years, the number of existing facilities to be managed and administrated have been increasing and this trend is expected to be continued.
- There are many aged facilities still to be in use.
  - There are many facilities constructed or installed (such as aged ACP or CI pipes) before handing over by Dutch company more than 40 years ago.
  - Therefore it is anticipated that there would be more and more facilities to be renewed and/or rehabilitated in future.

Under such situations, it is anticipated that the cost for O&M would demonstrate upward trend in future.

In order to ensure sustainable development, with maintaining quality of services with a limited budget, long-term cost saving approach should be taken under efficient O&M planning. To realize this approach, appropriate asset management, incorporated the following ideas, should be considered in the master plan.

- To forecast future situation of existing facilities based on appropriate inspection/evaluation.
- To know appropriate timing of necessary action (e.g., rehabilitation/renewal) to minimize cost.

Figure 15.4.1 shows the necessity and concept of the appropriate asset management. The important points of the appropriate asset management are summarized as below:

- To grasp existing condition
  - To organize asset registration system to know the locations and status of the existing facilities.
  - To ensure quick and smooth access to the registration system for whom it may

concern.

- To forecast future condition
  - To assess remaining lifetime of existing facilities based on analysis of existing condition.
  - To estimate necessary timing, contents and cost for rehabilitation/renewal.
- Appropriate planning and management
  - To formulate cost-effective rehabilitation/renewal planning based on appropriate future forecast.
  - To forecast best timing for rehabilitation/renewal.
  - To conduct efficient O&M.

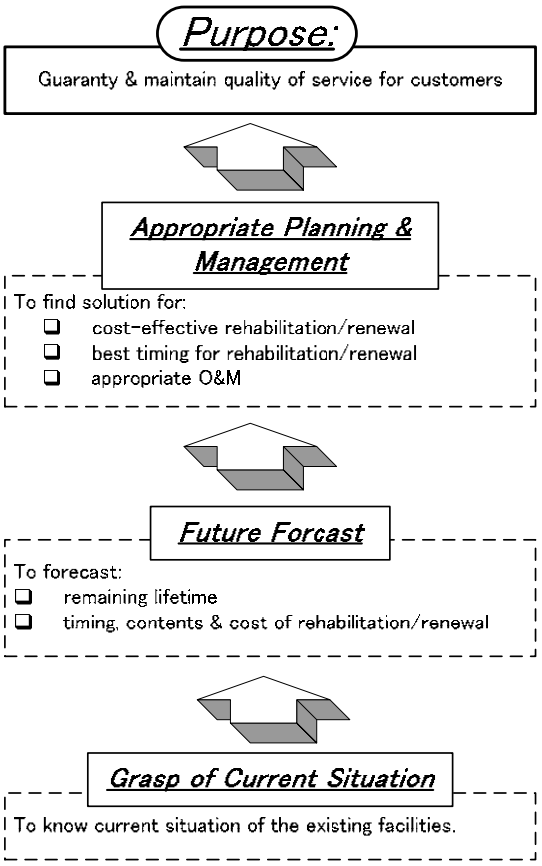


Figure 15.4.1 Concept of Appropriate Asset Management

Table 15.4.1 summarizes possible advantages and merits to be brought by an effective and appropriate asset management.

Table 15.4.1 Possible Advantages and Merits by Appropriate Asset Management

Possible Advantages & Merits (but not limited to the followings)	*Merits on:*		
	O&M	*In case of Emergency & Accident*	*Facility Investment & Planning*
To-do lists for daily O&M are systematically organized.	○		
Necessary materials/equipments (e.g., spare parts or chemicals) are properly organized for smooth procurement or stock inventory management.	○		
Quick response can be smoothly taken in case of emergency.		○	
Appropriate mid- and long term planning for O&M including rehabilitation/renewal can be efficiently formulated.			○
Location of asset can be easily identified.	○	○	○
Priority of critical/important assets can be adequately ordered.	○	○	○
Efficient operation can be ensured.	○		
Better communication with customers can be established.	○	○	
Appropriate and reasonable tariff can be set based on correct and proper information.			○
Consensus of customers regarding tariff revision can be smoothly obtained.			○
Appropriate renewal/rehabilitation based on original needs of service providers or customers can be assured.	○		○

However, water service providers in the Study Area are faced with the following difficult problems and they would be the major constrains for inappropriate O&M condition.

- Existing drawings are not kept in record properly.
- Inventory of existing facilities are not systematically kept in record.

Considering the current situation of water service providers in the Study Area, inventory of existing facilities must be properly organized for the first step toward appropriate asset management.

As mentioned above, appropriate asset management should be incorporated in formulation of master plan, with a special attention to the followings:

- What kind of information/data should be collected and kept in record?
- How should these information/data be fed back to daily O&M?
- How should flow of information/data be arranged?

In addition, proper institutional and organization structure should be examined in master planning stage so that organization in charge of O&M can do followings:

- Access information/data organized under proper asset management whenever necessary.
- Formulate appropriate O&M planning based on the information/data.
- Implement appropriate O&M based on the information/data.

15.4.2 Special Attentions for Community Water Supply

At present, PU gets involved in construction of facilities and the system is handed over to a Water User Organization (WUO) organized by villagers after completion of construction. Daily O&M including tariff setting or revenue collection are responsible of WUO.

However, as mentioned in Chapter 6 of this Technical Report, conditions of O&M differ widely from place to place. In poorly-managed place, there are many cases that troubled or damaged facilities are unsolved to be left neglected or pump is repeatedly broken down due to mis-operation.

O&M with full cost recovery thoroughly by water utility user would be an almost ideal and perfect situation. For full entrustment to users and full cost recovery, however, it is vital that WUO members (in short, villagers) shall have sufficient capacity for daily O&M and technical follow-up by expert of PDAM or PU shall be available whenever necessary. Without rescues for these basic requirements, it would be quite difficult to set up appropriate tariff structures or O&M program. If revenue cannot be collected sufficiently, WUO cannot save enough money to cover minimum requirements for daily O&M and repair costs, and this would result in malfunction of water supply system.

Therefore, following matters should be considered for adequate and sustainable O&M:

- Identify what WUO, PU or PDAM can do to make clear demarcation of their role (examples are given in Table 15.4.2 and Table 15.4.3).
- Consolidate legal systems for clear demarcation of roles of WUO, PU and PDAM.
- Implement capacity development program for:
  - WUO who are directly involved in daily O&M.
  - PU and PDAM specialists who are expected to undertake advisory role to WUO members, who should have leadership/ownership.

With respect to the above-mentioned capacity development measures for appropriate O&M of community water supply systems, further discussion with organization concerns including PUs and PDAMs shall be indispensable in time of future master planning stage.

Table 15.4.2 Demarcation of Roles and Capacities for Related Persons/Parties for Community Water Supply (Example)

Person in Charge			*Contents of Role*	*Required Capacity/Knowledge*
Residents	Residents (user)		* Assist person in charge for O&M * Cleanup duty for facilities (water tap, intake, reservoir, distribution pipe, ditch, etc.)	* No special knowledge is required
	WUO	Responsible for O&M	* O&M for facilities, minor repair work, etc.	* Basic knowledge on O&M including repair work for water supply facilities * Basic knowledge on public health and sanitation
		Responsible for Administration	* Administration of facilities * Promotion of awareness for public health and sanitation	* Basic knowledge on administration, public health and sanitation
Public Organization	Engineer of PU		* Major repair work * Construction supervision for facilities	* Technical skill and knowledge on construction & repair of water supply facilities, water quality analysis and measurement of water volume * Knowledge on administration, public health and sanitation
	Engineer of PDAM		* Water quality analysis * Monitoring of water supply activities	

Table 15.4.3 Required Activities for Operation and Maintenance by Related Persons/Perties for Community Water Supply (Example)

	Activity	Frequency	Done by	Required Material and Tools	
				Material	Tools
Spring and River	Intake Cleaning & Maintenance	Every month	Responsible person for O&M of WUO		Shovel, tool kit, etc.
	Inspection of Transmission Pipe	Every 2 weeks	Responsible person for O&M of WUO		
	Flow Rate Measurement	Twice a Year (Wet & Dry Season)	Responsible person for O&M of WUO		Bucket, stop watch
	Water Quality Analysis	Twice a Year (Wet & Dry Season)	Engineer of PU/PDAM	Simple analysis kit, sampling bottle	Bucket for sampling
	Filter Tank Cleaning	Every month	Responsible person for O&M of WUO User (member of WUO)		Cleaning kit including bucket & brush
	Reservoir Cleaning	Every month	Responsible person for O&M of WUO User (member of WUO)		Cleaning kit including bucket & brush
	Tap & Drainage Cleaning	Every 2 months	Responsible person for O&M of WUO User (member of WUO)		Shovel, tool kit, etc.
	Minor Repair Work	As necessary	Responsible person for O&M of WUO	Spair parts (fitting, faucet, pipe, etc.)	Repair kit Repair tool including wrench & saw
	Major Repair Work	As necessary	Responsible person for O&M of WUO Engineer of PU/PDAM	Spair parts	Repair kit Repair tool including wrench & saw
	Repair of Fence around Public Tap	As necessary	Responsible person for O&M of WUO User (member of WUO)	Timber, nail, fence, etc.	Tool kit including saw & hammer
	Repair of Fence around Intake	As necessary	Responsible person for O&M of WUO User (member of WUO)	Timber, nail, fence, etc.	Tool kit including saw & hammer
	Inspection of Distribution Pipe	As necessary	Responsible person for O&M of WUO User (member of WUO)		
Shallow Well	Inspection, Cleaning & Maintenance of Pump	Every week	Responsible person for O&M of WUO User (member of WUO)		Cleaning kit including bucket & brush
	Drainage Cleaning	Every month	Responsible person for O&M of WUO User (member of WUO)		Shovel, tool kit, etc.
	Well Cleaning	Every 6 months	Responsible person for O&M of WUO User (member of WUO)		Cleaning kit including drain pump & shovel
	Water Quality Analysis	Every 3 months	Engineer of PU/PDAM	Simple analysis kit, sampling bottle	Bucket for sampling
	Repair of Fence	As necessary	Responsible person for O&M of WUO User (member of WUO)	Timber, nail, fence, etc.	Tool kit including saw & hammer
	Repair of Foundation & Drainage	As necessary	Responsible person for O&M of WUO User (member of WUO)	Cement, sand & gravel, timber, nail, etc.	Tool kit including convex, bucket, shovel, saw, etc.
	Pipe Inspection	Every 2 weeks	Responsible person for O&M of WUO		
	Reservoir Cleaning	Every month	Responsible person for O&M of WUO User (member of WUO)		Cleaning kit including bucket & brush
	Tap & Drainage Cleaning	Every 2 months	Responsible person for O&M of WUO User (member of WUO)		Shovel, tool kit, etc.
	Minor Repair Work	As necessary	Responsible person for O&M of WUO	Spair parts (fitting, faucet, pipe, etc.)	Repair kit Repair tool including wrench & saw
	Major Repair Work	As necessary	Responsible person for O&M of WUO Engineer of PU/PDAM	Spair parts	Repair kit Repair tool including wrench & saw
	Repair of Fence around Public Tap	As necessary	Responsible person for O&M of WUO User (member of WUO)	Timber, nail, fence, etc.	Tool kit including saw & hammer
Deep Well	Inspection, Cleaning & Maintenance of Pump	Every week	Responsible person for O&M of WUO User (member of WUO)		Cleaning kit including bucket & brush
	Drainage Cleaning	Every month	Responsible person for O&M of WUO User (member of WUO)		Shovel, tool kit, etc.
	Water Quality Analysis	Twice a Year (Wet & Dry Season)	Engineer of PU/PDAM	Simple analysis kit, sampling bottle	Bucket for sampling
	Repair of Fence	As necessary	Responsible person for O&M of WUO User (member of WUO)	Timber, nail, fence, etc.	Tool kit including saw & hammer
	Repair of Foundation & Drainage	As necessary	Responsible person for O&M of WUO User (member of WUO)	Cement, sand & gravel, timber, nail, etc.	Tool kit including convex, bucket, shovel, saw, etc.
	Repair & Maintenance of Deep Well	As necessary	Responsible person for O&M of WUO Engineer of PU/PDAM	Spair parts	Repair kit
	Pipe Inspection	Every 2 weeks	Responsible person for O&M of WUO		
	Reservoir Cleaning	Every month	Responsible person for O&M of WUO User (member of WUO)		Cleaning kit including bucket & brush
	Tap & Drainage Cleaning	Every 2 months	Responsible person for O&M of WUO User (member of WUO)		Shovel, tool kit, etc.
	Minor Repair Work	As necessary	Responsible person for O&M of WUO	Spair parts (fitting, faucet, pipe, etc.)	Repair kit Repair tool including wrench & saw
	Major Repair Work	As necessary	Responsible person for O&M of WUO Engineer of PU/PDAM	Spair parts	Repair kit Repair tool including wrench & saw
	Repair of Fence around Public Tap	As necessary	Responsible person for O&M of WUO User (member of WUO)	Timber, nail, fence, etc.	Tool kit including saw & hammer

15.5 Issues on Water Quality Management

An appropriate water quality management strategy should be incorporated into the future master

plan. An effective water quality management aims and will ensure the followings:

- the protection of public health by assuring a safer water supply
- improved consumer confidence in water quality and trust of the water service provider
  - improved communication with consumers and employees
  - better-informed consumers and employees
- demonstrate commitment by the water service provider to a quality management system, to demonstrate due diligence
- clearly defined levels of service and performance indicators

However, due to lack of systematic water quality management strategy, water supply providers in the Study Area have not earned full-scale trust by customers. As shown in Figure 15.5.1, if a water service provider fails to gain the trust of customers in the future,

- it cannot complete their social obligations to supply safe water,
- then it would lose credibility of customers,
- then it would be difficult to have a consensus in revision of tariff,
- then it would get into difficulty in maintaining quality of service,
- then it would get much more difficulties in providing safe water.

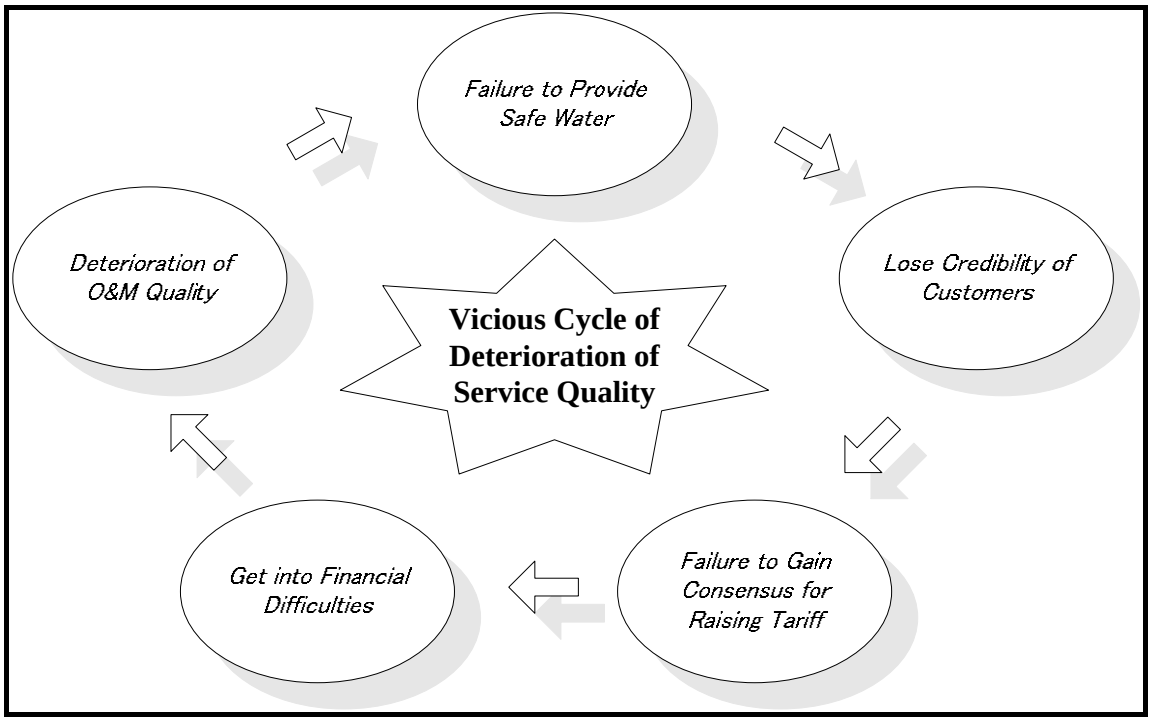


Figure 15.5.1 Vicious Cycle of Deterioration of Service Quality

As mentioned above, appropriate water quality management is one of key elements for formulation of master plan to ensure sustainable & steady water supply service, with keeping good quality.

Following issues should be considered to establish appropriate water quality management, with reference to the "Water Safety Plans" by WHO:

- Monitoring of water source with reference to the relevant guidelines and standards
  - Water source should be monitored from the viewpoint of its protection.
  - Water source should be monitored to respond any possible contamination and/or accident.
- Monitoring of treated water with reference to the relevant guidelines and stand
  - Treated water should meet drinking water guidelines after treatment.
  - Treated water in reservoirs should be monitored and additional injection points for chlorination should be considered if necessary.
- Monitoring of treated water in distribution systems
  - Sampling points for residual chlorine should be fixed.
  - Sampling should be conducted at regular intervals.
- Furnishing laboratory
  - Laboratory should be furnished so that necessary monitoring items can be analyzed.
  - In case it is difficult for the laboratory of PDAMs or PU, to accommodate all necessary analysis items, outsourcing of analysis and/or sampling should be considered.
  - Training program for water quality monitoring should be implemented to develop capacity of laboratory staff or engineers in PDAM or PU
- Water quality monitoring for community water supply system
  - Water source and reservoirs should be monitored at regular intervals, with the assistance of engineers of PDAM.
- Coordination with MOH
  - Demarcation of role should be clarified among PDAM, PU and MOH.
  - Monitoring data should be shared among organization concerned.
  - Institutional framework should be established for smooth data access and efficient implementation of water quality management.

15.6 Issues on Financial Aspect

15.6.1 Issues on Each PDAM

(1) PDAM Yogyakarta

Financial management is generally efficient as mentioned in Chapter 7. According to SWOT analysis, however, there are some weakness in operation and maintenance. In the master plan the PDAM should consider renewal and expansion investment to decrease NRW and increase service coverage based on the discussed policy and strategy. It is observed that service coverage decreased at the latest data in 2005. According to financial analysis there is room to raise funds for investment by debt financing. Therefore the master plan should cover the fund source recommendation with comparison of terms and conditions including donors offering.

It is also observed that there are illegal connections. To rectify such situation corporate

governance should be strengthened through capacity building.

Since water source is limited the regional government invited private sector investment through the DBOT project, which seems suspend for the PDAM to make independent investments. The master plan may not free from solution consideration on the DBOT project.

In the mean time, the PDAM is purchasing well water from Sleman and servicing residents in Sleman. Its mechanism should be clarified in the master plan to improve O&M with mutual agreement between 2 PDAMs. It is not avoidable to increase tariff due to source cost. Paradigm shift in tariff formation, affordability, cross subsidy should be discussed in civil society involvement as well as regulatory bodies under transparent policy.

(2) PDAM Sleman

Financial condition is critical as mentioned in Chapter 7. The PDAM is making effort to restore the financial problem under the regional government support such as water meter installation, cash flow injection and so on. However the central government urgent intervention is essential. Management confirmed to prepare necessary documentation for the application to the central government. In the master plan the process of financial reconstruction should be confirmed and rescue plan should be studied even further.

The PDAM has strength in water source but weakness in scattered population. Transfer of water supply system to communities in scattered population area will be studied. Cooperation with PDAM Yogyakarta is necessary for win-win solution by taking in advantage of gravity water source in Sleman.

Since financial data disclosure of PDAM Sleman is regarded advanced, the master plan study will be accomplished fruitful that is required to be completed by 1 January 2010 according to PP 16/2005.

(3) PDAM Bantul

Due to the recent earthquake disaster in the region, tariff revision has been suspended since 2002. Therefore, new tariff proposal will be the first priority for the master plan of the PDAM. In Indonesia, MOHA issued decree and tariff calculation guideline in 1998 but tariff decision is made by the regional government with civil society involvement. It is observed that non domestic tariff of the PDAM is relatively low in comparison with others, so cross subsidy from large user should be taken into account for its revision. After the disaster, the central government together with the regional government started to restore the condition. As discussed in Chapter 12.5.1 capacity development approach should be introduced to the PDAM

in order to strengthen corporate governance with transparency and accountability for establishment of good customer relations. The district, widely open to Indian Ocean, has potentiality for development by inviting foreign investors. Taking advantage of comprehensive development plan, the master plan of the PDAM should be studied. Disclosure of management and financial data will be enhanced.

(4) Cooperation among PDAMs

As discussed in Section 15.2.2, financial issues must be studied in the master plan.

15.6.2 Issues on Community Water Supply System

(1) Transparency

Transparent rule for construction procedure should be introduced. Tariff system should be standardized.

(2) Database Construction

Database construction is essential to monitor its sustainability and to invite donor's assistance or for budget planning by the regional PU. Annual report should be submitted from WUO to regional PU. Reporting items should be studied in the master plan.

(3) Capacity Building of WUO

Capacity building plan should be studied and a few cases may be implemented based on the master plan of PDAM Sleman.

Tariff depends on system components and beneficiaries affordability. Basic tariff should recover at least recurrent costs such as electricity, chemical, overhead tank cleaning, pomp operators' salary, periodical water quality test and so on. Full cost recovery requires depreciation cost for capital investment that may be considered as the regional PU responsibility for rural area. However it is recommended for WUO to keep some funds for urgent pomp repair cost to protect community lifeline before replacement by the PU.

15.7 Issues on Social and Environmental Aspects

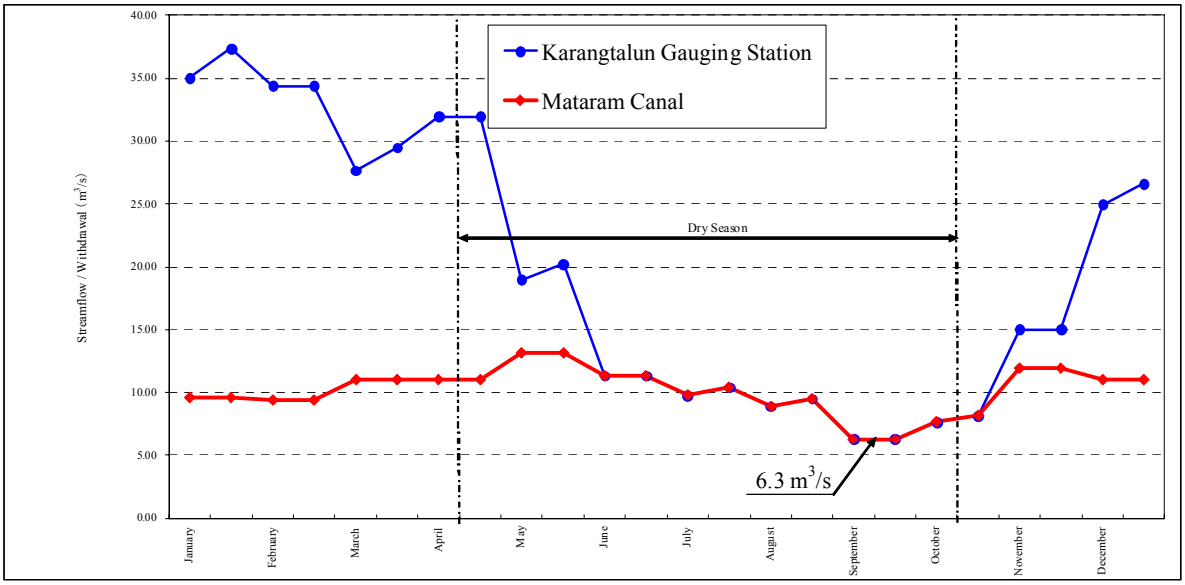
15.7.1 DBOT Bulk Water Supply Project

(1) River Discharge and Mataram Canal Flow

The DBOT Bulk Water Supply Project will depend its water source on Mataram Canal which is

from the Progo River. As illustrated in Figure 15.7.1, the Progo River's mean monthly discharge which is measured at Karangtalun gauging station and withdrawals by Mataram Canal decrease to 6.3m^3/s in dry season. Remaining water flow of Mataram Canal is finally discharged at least 0.5m^3/s into the Opak River. Since water quantity which will be used for the Bulk Water Supply Project is 1.0m^3/s from the Mataram canal and this quantity seems significant comparing to the total water flow in dry season, availability of water source for the Bulk Water Supply Project should be carefully confirmed.

Season	Rainy Season								Dry Season										Rainy Season					
Month	January		February		March		April		May		June		July		August		September		October		November		December	
Fifteen-day	1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
Karangtalun Gauging Station	35.03	37.36	34.39	34.39	27.63	29.48	31.94	31.94	18.96	20.22	11.32	11.32	9.77	10.42	8.90	9.50	6.30	6.30	7.64	8.15	15.01	15.01	24.94	26.60
Mataram Canal	9.63	9.63	9.40	9.40	11.04	11.04	11.01	11.01	13.15	13.15	11.32	11.32	9.77	10.42	8.90	9.50	6.30	6.30	7.64	8.15	11.94	11.94	11.05	11.05



Source: *Feasibility Study on DBOT Progo River (Mataram Canal) Bulk Water Supply Project for Yogyakarta City, Sleman Regency and Bantul Regency in the Yogyakarta Special Province, Yogyakarta Water Supply Sector Project (YWSSP), 2005, PT. Citra Tirta Mataram*

Figure 15.7.1 Progo River's Mean Monthly Discharge at Karangtalun Gauging Station and Withdrawals by Mataram Canal

(2) Land Acquisition and Resettlement for Treatment Plants and Reservoirs

Under the DBOT Bulk Water Supply Project, raw water from the Mataram Canal will be treated at water treatment plant in Bligo. Bligo water treatment plant (tentatively named) is planned to be constructed within the provincial domain with an area of approximately 10ha along the Mataram Canal. Currently, this land has being mainly utilized as paddy field and there are two small brickyards and seven farmhouses. The construction of the water treatment plant will not require large-scale resettlement. In addition, the raw water transmission channel with about 3km in length was planned within the right-of-way of the Mataram Canal and this will not require additional land acquisition.

Three distribution reservoirs are also planned to be constructed (it may include expansion of existing reservoir) under the Bulk Water Supply Project for respective PDAMs. Although the

detailed information concerning these reservoirs is not available, requirements of land acquisition or resettlement should be confirmed for following planned reservoirs if they were planned to be constructed in the Master Plan.

- Blimbingan reservoir (PDAM Sleman)
- Gemawang reservoir (PDAM Yogyakarta)
- Tambak reservoir (PDAM Bantul)

(3) Water Rights and Stakeholders

With regard to the additional water diversion from the Mataram Canal for the Bulk Water Supply Project, public hearings or conferences among various stakeholders have not been held so far. Under such situation, whether the consensus concerning water abstraction for water supply by farmers (the majority of stakeholders) is positive or not is still uncertain.

Major stakeholders concerning the diversion from the Mataram Canal will be as follows.

- Irrigation association (farmers)
  - Mataram irrigation system
  - Van der Wijck irrigation system
  - Opak River left bank irrigation system
  - Opak River right bank irrigation system
  - Kebonongan irrigation system
- Inhabitants along Mataram Canal, Van der Wijck Canal and Opak River
- Madukismo sugarcane mills
- Industrial water users
- Aquaculture (freshwater fish or spiny lobster) industry group and those farmers as a side job on aquaculture
- Micro hydropower generation by Van der Wijck Canal

15.7.2 Magelang Springs

In the history of the DBOT Bulk Water Supply Project, there was an alternative plan which spring water in Magelang Regency, outside of DIY Yogyakarta, would be transmitted to Yogyakarta. Development/utilization of the existing springs in Magelang Regency is depend on the approval of Central Java Province, agreement between Magelang Regency and DIY Yogyakarta, and consensus among stakeholders in Magelang Regency. However, whether the consensus by stakeholders is positive or not was still unexplained. And it seems quite difficult to have such consensus because the ruling of unbiased allocation on the customary water right is very tough.

15.7.3 Kamijoro Intake Weir Project

Kamijoro Intake Weir Project is planned to directly withdraw the river flow of 1.0m3/s for water supply from the downstream of Progo River which is boundary of Bantul Regency.

However, the said project for additional water supply purpose was just a desk plan without even Terms of References so that either the pre-feasibility or feasibility study was not put into practice. Moreover, whether the consensus by farmers (the majority of stakeholders) is positive or not is unpredictable.

15.7.4 Others

Other issues to be considered with regard to social and environmental consideration are:

- Impact of ground water exploitation.
- Necessity of improvement of sanitary facilities in response to future increase of wastewater volume which would be brought by increase of water supply volume.
- Negative impacts during construction stage.
- Task for environmental monitoring plan.

15.8 Other Issues

15.8.1 DBOT Bulk Water Supply Project

This JICA Study is regrettably terminated before commencement of preparation of Mater Plan which was originally included as one of the study objectives because of suspension of the DBOT Bulk Water Supply Project. Since the bulk water supply project is located upstream of water supply system, difficult situation of preparation of water supply master plan will not change without resolution of the DBOT Project. Therefore, before commencement of the preparation of the master plan, scope, conditions, and formation etc. of the DBOT Bulk Water Supply Project should be clearly planned and agreed among agencies concerned.

On the other hand, the provincial government of DIY could not provided information, without water supply master plan, to private firms of the DBOT Bulk Water Supply Project concerning water demand, when, where, and how much it would be required . Because of absence of such concrete and important information/requirements, mutual communication between the DIY provincial government and private firms seems not effectively established and this may cause suspension of the DBOT Project.

15.8.2 Issues on Water Source

(1) DBOT Project

Pricing information of the DBOT project is very limited, and beneficiary PDAM has dubious about price of raw water to be distributed. More over, since the difference between offering price of the DBOT project and the current production unit cost of PDAM is so large, compromise among them may be impossible (offering price for Rp 1,600/m^3 while bit price for Rp 1,100-1,200/m^3).

Since the government must develop water source in the area, it may be required to make equity investment for development funding to reduce construction cost. After the mutual disclosure of pricing information among stakeholders with the involvement of civil society, a paradigm shift in tariffs should be studied as referred to Chapter 12.5.2 (1) Legislative Improvement and (2) Public Service Obligation concept. WTP research reveals beneficiary primary concerns are quality, quantity and continuity.

Under the agreement, PDAMs have to build water treatment plants. Medium term project justification should be studied in the master plan through financial and economic evaluation with comparison of water source alternatives, that are bulk water, under ground water or else.

(2) Coordination among PDAMs

Under the Kartamantur initiative, coordination among PDAMs is essential. Effective usage of limited water source and conservation should be studied in the master plan according to capacity development approach discussed in Chapter 12.5.1(3) and (4) including community water supply through strengthening the capacity of water user organizations.

The central government advises through BPPSPAM for sector monitoring especially finance evaluation will be useful for sustainable O&M improvement and capacity building.

15.8.3 Consideration on Sanitation System

The Master Plan which is discussed in this chapter is for future water supply system. However, sanitation system improvement should also be taken into account in the Master Plan. There is a possibility that the sanitation situation would be worsen by improvement of water supply system.

Adequate and appropriate sanitation system should be considered and planned to protect public water bodies.

Furthermore, people and PDAM also depend on shallow wells as their water sources. The shallow well will be easily affected by contamination of surrounding water environment. To protect groundwater quality, improvement of sanitation is also indispensable.

As an option of sanitation system, there will be three types as follows.

- Sewerage (off-site, centralized system)
- Community plant system (off-site, decentralized system)
- On-site system (septic tank, leaking pit)

Type of sanitation system will be proposed by considering following conditions which will be studied in the Master Plan.

- Population density,
- Land use,
- Geographical, topographical conditions,
- Infiltration ability (soil permeability), and
- Cost effectiveness.