C. OUTLINE OF WATER QUALITY INVESTIGATION

1. OUTLINE OF INVESTIGATION

Water quality investigation is composed of Water quality investigation for water supply and Salinity investigation for salt water intrusion. Outline of these investigations are described below.

(1) Water quality investigation for water supply

Purpose of this investigation is to understand the existing water quality of Water source, WTP, S/R, P/S and Water supply tap. In addition, pesticide analysis of 1 raw water and 4 river water samples (Total 7 samples) were added.

Selection of sampling point

Sampling point and number of sample of this investigation are;

- Raw water: 8 points, 12 samples (Reservoir: 7 and River / Creak water: 5)
- WTP: 3 points, 12 samples (Raw water: 6 and Treated water: 6 samples)
- S/R: 1 point, 2 samples
- P/S: 1 point, 2 samples
- Water supply tap: 2 points, 4 samples

Total: 15 points, 32samples

List of sampling point is described in Table C.1 and Table C.3. Water quality investigation is done 2 times: once in rainy season and another in dry season. Through this investigation, safeness of water source and water supply system are verified.

Table C.1 List of Sampling Point

Sample No.	Location	Sampling point	Number of sample
WS – 1	Raw water (Reservoir)	Ngamoeyeik R.	2
WS – 2		Gyobyu R.	2
WS – 3		Hlawga R.	2
WS – 18		Lagunbyin R.	1 (Dry season)
WS – 5	Raw water (River water and Creek : planned site)	Kokkowa River	2
WS – 6		Hlaing River	1 (Rainy season)
WS – 16		Toe River	1 (Dry season)
WS – 17		Ngamoeyeik Creek	1 (Dry season)
WS – 4, 11	WTP	Nyaunghnapin WTP (Raw water and Treated water)	4
WS – 7, 12		Thaephyu WTP (Deep well and Treated water)	4
WS – 8, 13		South Dagon No.2 WTP (Deep well and Treated water)	4
WS – 9	P/S	Yegu P/S	2
WS – 10	S/R	Kokine S/R	2
WS – 14	Water supply tap	Water supply tap A (Dagon T/S YCDC office)	2
WS – 15		Water supply tap B (Thingangyun T/S YCDC office)	2
Total			33

Analysis item

Analysis item (24 items) is described below;

Water temperature, pH, Electrical conductivity (EC), Turbidity, Color, Hardness, total dissolved solid (TDS), Ammonium nitrogen, Nitrate nitrogen, Nitrite nitrogen, Chloride ion, Sulfate ion, Cyanide, Fluorine, Arsenic, Copper, Iron, Manganese, Lead, Selenium, Sodium, Zinc, Total coliform bacteria and E. Coli.

For Kokkowa River, Hlaing River and Nyaunghnapin WTP (raw water), pesticide (organophosphoric and organochloric) are analyzed.

Modification of investigation plan

From the preparatory investigation of sampling point, investigation plan is modified. Modification is described in following table.

Table C.2 List of Modification of Investigation Plan

Item	Initial plan	Modified plan	Reason of modification
Sampling point	13 points	15 points	In the initial investigation plan, WTP sampling point was 1 WTP (Thaephyu WTP or Yangonpauk WTP). On the contrary, in the execution plan, WTP sampling point was increased to 3 WTPs (Nyaunghnapin WTP, Thaephyu WTP and South Dagon No. 2 WTP) Moreover, New water source (Toe River, Ngamoeyeik Creek and Lagunbyin R) was added.
Analysis item (Biological index)	Standard plate count	E. Coli	Considering the drinking water standard of Myanmar, E. Coli was measured instead of standard plate count.
Number of analysis item	25 items	24 items	Through the preparatory investigation, it was cleared that chlorination was done in Yegu P/S, and other water works facilities (e.g. WTP, S/R) didn't do chlorination. Therefore, investigation of residual chlorination was canceled. Instead of that, residual chlorination and biological index investigation in Yegu P/S service area is planned. This additional investigation is implemented in dry season.

(2) Tap water quality investigation

This investigation is implemented to know the effect of chlorination in YCDC tap water. Sampling point is decided within Yegu P/S service area.

Detailed sampling point is decided through discussion with YCDC personnel.

Selection of sampling point

Sampling is done in following water works facility and T/S.

Waterworks facility: Yegu P/S, Kokine S/R

Domestic water tap: Yankin T/S, Dagon T/S, Pabedan T/S, Latha T/S, Lanmadaw T/S, Sanchaung T/S, Ahlone T/S and Kyimyindaing T/S

Analysis Item

Analysis item (8 items) is described below;

Water temperature, pH, Electric conductivity (EC), Turbidity, Total dissolved solid (TDS), Free chlorine, Total coliforms and Fecal coliform

(3) Salt water intrusion survey

This survey is implemented to understand the condition of salt water intrusion of Kokkowa River and Toe River. Investigation was implemented both high tide and low tide period in dry season.

Selection of sampling point

Sampling point is shown below.

In high tide period survey, sampling point is decided as follows;

- Upstream of water intake point: 2.5km and 5 km from water intake point
- Water intake point: 3 point on cross section
- Downstream of water intake point: 2.5km and 5 km from water intake point

Water sample is obtained from surface and lower layer (about -5m).

In low tide period survey, sampling point is decided as follows;

- Around upper limit of salt water invasion: 3 point on cross section

Table C.3 Sampling Point of Saltwater Intrusion Survey

River	Sampling point
Toe River	High tide Upstream from water intake point (2): 5km from intake point − Surface water: 1 sample − Lower layer water: 1 sample Upstream from water intake point (1): 2.5km from intake point − Surface water: 1 sample − Lower layer water: 1 sample Water intake point − 3 points on cross section − Surface water: 3 sample − Lower layer water: 3 sample Downstream from water intake point (1): 2.5km from intake point − Surface water: 1 sample − Lower layer water: 1 sample Downstream from water intake point (2): 5km from intake point − Surface water: 1 sample − Lower layer water: 1 sample Total: 14 sample
	Low tide Upper limit of salt water invasion − 3 points on cross section

River	Sampling point
	− Lower layer water: 3 sample Total: 3 samples
Kokkowa river	<u>High tide</u> Upstream from water intake point (2): 5km from intake point − Surface water: 1 sample − Lower layer water: 1 sample Upstream from water intake point (1): 2.5km from intake point − Surface water: 1 sample − Lower layer water: 1 sample Water intake point − 3 points on cross section − Surface water: 3 sample − Lower layer water: 3 sample Downstream from water intake point (1): 2.5km from intake point − Surface water: 1 sample − Lower layer water: 1 sample Downstream from water intake point (2): 5km from intake point − Surface water: 1 sample − Lower layer water: 1 sample Total: 14 sample
	<u>Low tide</u> Upper limit of salt water invasion − 3 points on cross section − Lower layer water: 3 sample Total: 3 samples

<u>Analysis Item</u>

Analysis item (5 items) is described below;

Water temperature, pH, Electric conductivity (EC), Total dissolved solid (TDS), and Chloride ion

2. RESULT OF WATER QUALITY INVESTIGATION

Sampling in rainy season was implemented from September 11 to 17, 2012, and sampling in dry season was implemented from March 8 to April 1, 2013. Coordinates and sampling date / time of each sampling point are shown in following table. Analysis result is shown in Table C.4.

Table C.4 Information of Sampling Point

Sample No.	Sampling Points	Positional Information	Rainy season		Dry season	
			Date	Time	Date	Time
WS-1	Ngamoeyeik Reservoir	47Q 198122E 1921093N	9/11	10:10	4/1	10:04
WS-2	Gyobyu Reservoir	47Q 185129E 1923559N	9/17	12:25	4/1	10:04
WS-3	Hlawga Reservoir	47Q 192909E 1878761N	9/17	14:25	3/11	15:07
WS-4	Nyaunghnapin WTP (Raw water)	47Q 197744E 1892155N	9/11	12:30	3/11	16:03
WS-5	Kokkowa River	46Q 804421E 1876803N	9/12	9:30	3/8	16:34
WS-6	Hlaing River	46Q 809257E 1903854N	9/17	10:25	---	---
WS-7	Deep well (at Thaephyu WTP)	46Q 816156E 1875071N	9/12	11:00	3/8	17:20
WS-8	Deep well (at South Dagon No.2 WTP)	47Q 205879E 1865854N	9/12	13:00	3/11	11:26
WS-9	Yegu pump station	47Q 197283E 1866079N	9/11	14:00	3/11	10:26
WS-10	Kokine distribution tank	47Q 196805E 1861235N	9/11	14:30	3/9	17:12
WS-11	Nyaunghnapin WTP (Treated water)	47Q 197489E 1892044N	9/11	12:45	3/11	16:18
WS-12	Thaephyu WTP (Treated water)	46Q 816156E 1875071N	9/12	10:55	3/8	17:30
WS-13	South Dagon No.2 WTP (Treated water)	47Q 205879E 1865854N	9/12	13:05	3/11	11:36
WS-14	Water tap (A)	47Q 196339E 1858751N	9/11	15:30	3/19	15:56
WS-15	Water tap (B)	47Q 200467E 1862782N	9/12	13:35	3/19	16:31
WS-16	Toe River	46Q 0807443E 1840621N	---	---	3/8	13:18
WS-17	Ngamoeyeik Creek	47Q 207414E 1877846N	---	---	3/25	17:04
WS-18	Lagunbyin Reservoir	47Q 214079E 1909176N	---	---	3/11	17:29

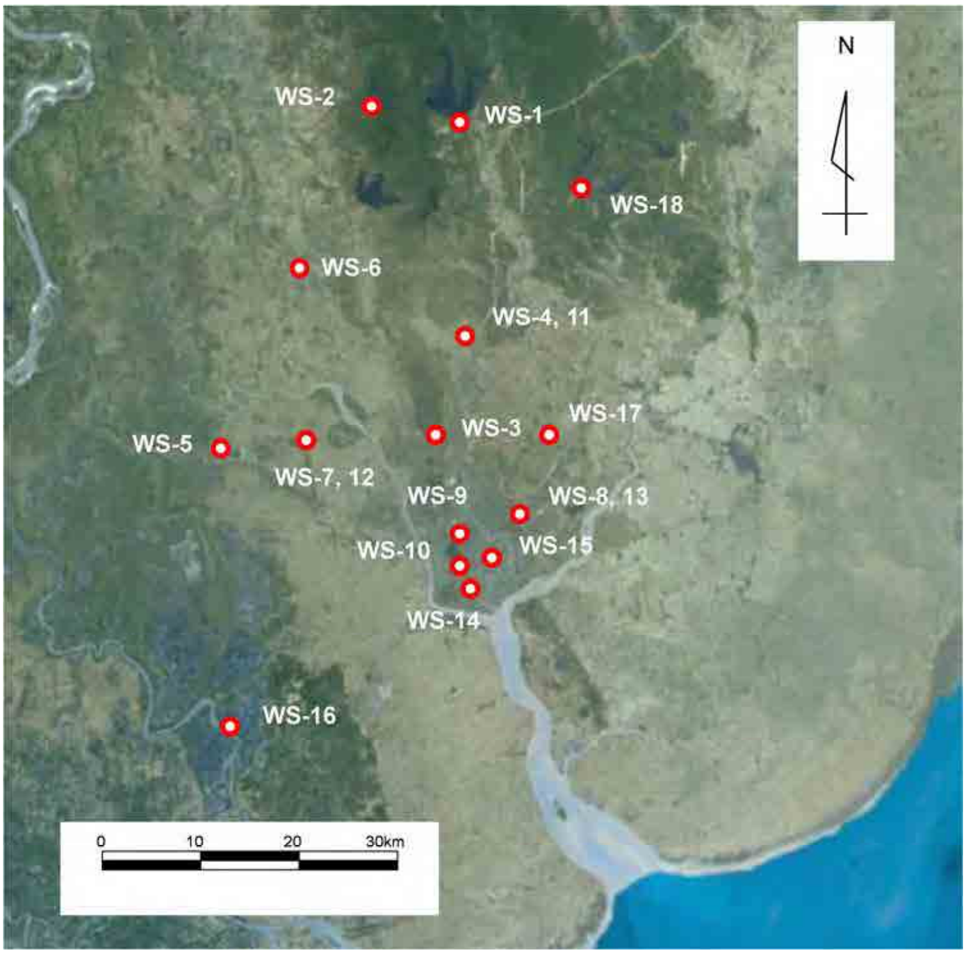


Figure C.1 Sampling Point (Location of All Sampling Point)

Table C.5 Result of Water Quality Analysis, Rainy Season (1)
Reservoir and River Water

Parameter	Unit	Ngamoeyeik Reservoir	Gyobyu Reservoir	Hlawga Reservoir	Kokkowa River	Hlaing River
		WS – 1	WS – 2	WS – 3	WS – 5	WS – 6
Air Temperature	^{o}C	32	30	30	29	31
Water Temperature	^{o}C	29	29.8	29.4	28.3	18.7
pH	-	7.4	7.8	7.1	7.8	7.6
Electrical Conductivity	μS/cm	137	64	30	24	85
Turbidity	NTU	5	5	22	365	190
Color	TCU	<5	<5	<5	180	110
Ammonium Nitrogen	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.
Arsenic (As)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Chloride (Cl^-)	mg/l	4	2	5	4	4
Copper (Cu)	mg/l	<1.00	<1.00	<1.00	<1.00	<1.00
Total Cyanide (CN)	mg/l	0.07	0.05	0.05	<0.03	<0.03
Cyanide (CN) *	mg/l	<0.0005	<0.0005	<0.0005	-	-
Cyanogen Chloride *	mg/l	<0.0005	<0.0005	<0.0005	-	-
Fluoride (F)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.
Hardness (mg/l as $CaCO_3$)	mg/l	42	32	20	54	52
Iron (Fe)	mg/l	0.27	0.26	0.55	4.60	2.88
Manganese (Mn)	mg/l	<0.10	<0.10	<0.10	1.00	<0.10
Lead (Pb)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-nitrogen (as NO_3)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.
Nitrite-nitrogen (as NO_2)	mg/l	0.007	0.006	0.007	0.019	0.019
Selenium (Se)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium (Na^+)	mg/l	5.95	5.73	4.26	7.46	7.74
Sulfate (SO_4^{2-})	mg/l	16	Nil	Nil	20	14
Total Dissolved Solid (TDS)	mg/l	39	38	24	56	55
Zinc (Zn)	mg/l	<1.00	<1.00	<1.00	<1.00	<1.00
Total coliforms	-	Detected	Detected	Detected	Detected	Detected
Fecal coliforms	-	Detected	Detected	Detected	N.D.	Detected

* Re-analysis was done in Japan.

Table C.6 Result of Water Quality Analysis, Rainy Season (2) Raw Water and Treated Water

Parameter	Unit	Nyaunghnapin WTP		Thaephyu WTP		South Dagon No.2 WTP	
		Raw water	Treated water	Raw water	Treated water	Raw water	Treated water
		WS -4	WS -11	WS -7	WS -12	WS -8	WS -13
Air Temperature	^oC	29	29	36	36	32	36
Water Temperature	^oC	29	29	29.2	30.3	31.8	31.8
pH	-	7.0	7.3	7.2	7.3	7.0	7.7
Electric Conductivity	μS/cm	77	71	500	660	560	690
Turbidity	NTU	88	3	16	3	45	4
Color	TCU	40	<5	<5	<5	10	<5
Ammonium Nitrogen	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Arsenic (As)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chloride (Cl^-)	mg/l	4	4	39	111	52	85
Copper (Cu)	mg/l	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Total Cyanide (CN)	mg/l	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cyanide (CN) *	mg/l	-	-	-	-	-	-
Cyanogen Chloride *	mg/l	-	-	-	-	-	-
Fluoride (F)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Hardness (mg/l as $CaCO_3$)	mg/l	26	24	112	158	92	94
Iron (Fe)	mg/l	1.86	0.24	0.48	0.20	1.20	0.28
Manganese (Mn)	mg/l	<0.10	<0.10	0.30	<0.10	<0.10	<0.10
Lead (Pb)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-nitrogen (as NO_3)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Nitrite-nitrogen (as NO_2)	mg/l	0.021	0.007	0.076	0.016	0.006	0.121
Selenium (Se)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium (Na^+)	mg/l	4.76	4.58	46.5	117	96.5	127
Sulfate (SO_4^{2-})	mg/l	N.D.	N.D.	5	8	12	10
Total Dissolved Solid (TDS)	mg/l	28	29	169	285	233	289
Zinc (Zn)	mg/l	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Total coliforms	-	Detected	Detected	Detected	Detected	Detected	Detected
Fecal coliforms	-	Detected	Detected	N.D.	N.D.	Detected	Detected

* Re-analysis was done in Japan.

Table C.7 Result of Water Quality Analysis, Rainy Season (3)
Pump Station, Service Reservoir and Water Tap

Parameter	Unit	Yegu P/S	Kokine S/R	Tap (A)	Tap (B)
		WS -9	WS -10	WS -14	WS -15
Air Temperature	^{o}C	26	26	27	33
Water Temperature	^{o}C	28	28	29	29.2
pH	-	7.0	7.0	6.3	7.0
Electric Conductivity	μS/cm	89	82	88	66
Turbidity	NTU	3	18	5	26
Color	TCU	<5	<5	<5	<5
Ammonium Nitrogen	mg/l	N.D.	N.D.	N.D.	N.D.
Arsenic (As)	mg/l	<0.01	<0.01	<0.01	<0.01
Chloride (Cl^-)	mg/l	6	4	9	5
Copper (Cu)	mg/l	<1.00	<1.00	<1.00	<1.00
Total Cyanide (CN)	mg/l	<0.03	<0.03	<0.03	<0.03
Cyanide (CN) *	mg/l	-	-	-	-
Cyanogen Chloride *	mg/l	-	-	-	-
Fluoride (F)	mg/l	N.D.	N.D.	N.D.	N.D.
Hardness	mg/l	32	30	32	20
Iron (Fe)	mg/l	0.24	0.29	0.29	0.35
Manganese (Mn)	mg/l	<0.10	<0.10	<0.10	<0.10
Lead (Pb)	mg/l	<0.01	<0.01	<0.01	<0.01
Nitrate-nitrogen (as NO_3)	mg/l	N.D.	N.D.	N.D.	N.D.
Nitrite-nitrogen (as NO_2)	mg/l	0.005	0.006	0.006	0.003
Selenium (Se)	mg/l	<0.001	<0.001	<0.001	<0.001
Sodium (Na^+)	mg/l	5.95	5.95	6.72	4.52
Sulfate (SO_4^{2-})	mg/l	N.D.	N.D.	N.D.	N.D.
Total Dissolved Solid (TDS)	mg/l	36	35	39	26
Zinc (Zn)	mg/l	<1.00	<1.00	<1.00	<1.00
Total coliforms	-	Detected	Detected	Detected	Detected
Fecal coliforms	-	Detected	Detected	Detected	Detected

* Re-analysis was done in Japan.

Table C.8 Result of Water Quality Analysis, Dry Season (1)
Reservoir and River Water

Parameter	Unit	Ngamoeyeik Reservoir	Gyobyu Reservoir	Hlawga Reservoir	Kokkowa River	Toe River	Ngamoeyeik Creek	Lagunbyin Reservoir
		WS - 1	WS - 2	WS - 3	WS - 5	WS - 16	WS- 17	WS - 18
Air Temperature	^oC	32.0	35.5	40.0	34.5	38.0	36.0	34.0
Water Temperature	^oC	31.5	30.5	31.0	30.5	31.0	32.5	29.0
pH	-	8.75	7.93	7.62	8.24	8.28	7.42	6.65
Electric Conductivity	μS/cm	90	90	50	220	210	110	10
Turbidity	NTU	18	8	11	75	42	48	37
Color	TCU	<5	<5	<5	20	<5	15	<5
Ammonium Nitrogen	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Arsenic (As)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Chloride (Cl^-)	mg/l	4	3	11	11	10	10	5
Copper (Cu)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Total Cyanide (CN)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Fluoride (F)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Hardness (mg/l as $CaCO_3$)	mg/l	40	44	28	94	94	54	6
Iron (Fe)	mg/l	0.28	0.21	0.20	0.52	0.38	0.47	0.29
Manganese (Mn)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Lead (Pb)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Nitrate-nitrogen (as NO_3)	mg/l	N.D.	N.D	N.D.	N.D.	N.D.	N.D.	N.D.
Nitrite-nitrogen (as NO_2)	mg/l	0.005	0.005	0.002	0.006	0.069	0.006	0.006
Selenium (Se)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sodium (Na^+)	mg/l	8.89	8.63	6.81	19.4	14.9	11.8	2.86
Sulfate (SO_4^{2-})	mg/l	N.D.	N.D.	N.D.	5	4	N.D.	N.D.
Total Dissolved Solid (TDS)	mg/l	26	28	19	62	61	33	5
Zinc (Zn)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Total coliforms	-	Detected	Detected	Detected	Detected	Detected	Detected	Detected
Fecal coliforms	-	Detected	Detected	Detected	Detected	Detected	Detected	Detected

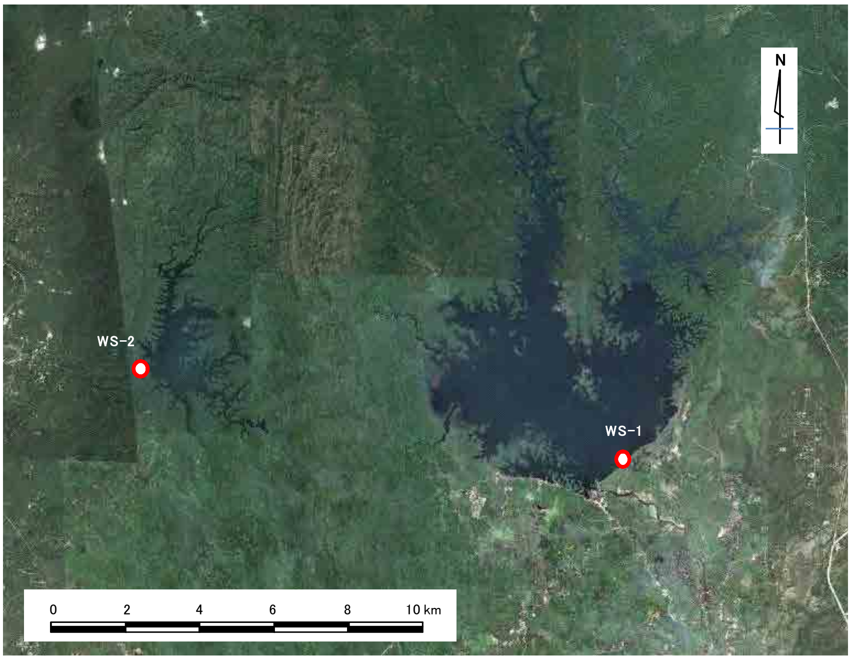
Table C.9 Result of Water Quality Analysis, Dry Season (2)
Raw Water and Treated Water

Parameter	Unit	Nyaunghnapin WTP		Thaephyu WTP		South Dagon No.2 WTP	
		Raw water	Treated water	Raw water	Treated water	Raw water	Treated water
		WS - 4	WS - 11	WS - 7	WS - 12	WS - 8	WS - 13
Air Temperature	^oC	41.0	36.0	36.0	36.0	33.0	33.0
Water Temperature	^oC	31.0	31.0	29.5	29.5	34.0	34.5
pH	-	7.67	7.88	7.12	7.12	6.79	7.77
Electric Conductivity	μS/cm	80	70	1001	585	530	530
Turbidity	NTU	26	6	12	36	8	7
Color	TCU	10	<5	<5	<5	<5	<5
Ammonium Nitrogen	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Arsenic (As)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Chloride (Cl^-)	mg/l	4	6	229	107	56	60
Copper (Cu)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Total Cyanide (CN)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Fluoride (F)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Hardness (mg/l as $CaCO_3$)	mg/l	44	38	234	154	104	90
Iron (Fe)	mg/l	0.38	0.27	0.24	0.33	0.16	0.1
Manganese (Mn)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Lead (Pb)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Nitrate-nitrogen (as NO_3)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Nitrite-nitrogen (as NO_2)	mg/l	0.014	0.004	0.431	0.008	0.018	0.006
Selenium (Se)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sodium (Na^+)	mg/l	7.44	9.71	158	103	91.1	74.2
Sulfate (SO_4^{2-})	mg/l	N.D.	N.D.	20	N.D.	11	N.D.
Total Dissolved Solid (TDS)	mg/l	26	26	283	161	131	140
Zinc (Zn)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Total coliforms	-	Detected	Detected	Detected	Detected	Detected	Detected
Fecal coliforms	-	Detected	Detected	Detected	Detected	Detected	Detected

Table C.10 Result of Water Quality Analysis, Dry Season (3)
Pump Station, Service Reservoir and Water Tap

Parameter	Unit	Yegu P/S	Kokine R.	Tap (A)	Tap (B)
		WS -9	WS -10	WS -14	WS -15
Air Temperature	°C	31.0	34.5	35.0	35.5
Water Temperature	°C	30.0	30.5	32.0	33.0
pH	-	7.19	7.68	7.58	7.32
Electric Conductivity	μS/cm	70	80	90	50
Turbidity	NTU	10	20	33	10
Color	TCU	<5	<5	<5	<5
Ammonium Nitrogen	mg/l	N.D.	N.D.	N.D.	N.D.
Arsenic (As)	mg/l	N.D.	N.D.	N.D.	N.D.
Chloride (Cl^-)	mg/l	7	3	5	6
Copper (Cu)	mg/l	N.D.	N.D.	N.D.	N.D.
Total Cyanide (CN)	mg/l	N.D.	N.D.	N.D.	N.D.
Fluoride (F)	mg/l	N.D.	N.D.	N.D.	N.D.
Hardness	mg/l	34	40	40	32
Iron (Fe)	mg/l	0.18	0.32	0.38	0.25
Manganese (Mn)	mg/l	N.D.	N.D.	N.D.	N.D.
Lead (Pb)	mg/l	N.D.	N.D.	N.D.	N.D.
Nitrate-nitrogen (as NO_3)	mg/l	N.D.	N.D.	N.D.	N.D.
Nitrite-nitrogen (as NO_2)	mg/l	0.003	0.006	0.006	0.004
Selenium (Se)	mg/l	N.D.	N.D.	N.D.	N.D.
Sodium (Na^+)	mg/l	9.43	11.2	6.46	6.65
Sulfate (SO_4^{2-})	mg/l	N.D.	N.D.	N.D.	N.D.
Total Dissolved Solid (TDS)	mg/l	24	26	25	21
Zinc (Zn)	mg/l	N.D.	N.D.	N.D.	N.D.
Total coliforms	n/ml	Detected	Detected	Detected	Detected
Fecal coliforms	-	Detected	Detected	Detected	Detected

Photo of sampling point



Sampling Point WS - 1 and WS - 2

Sampling Point WS - 3

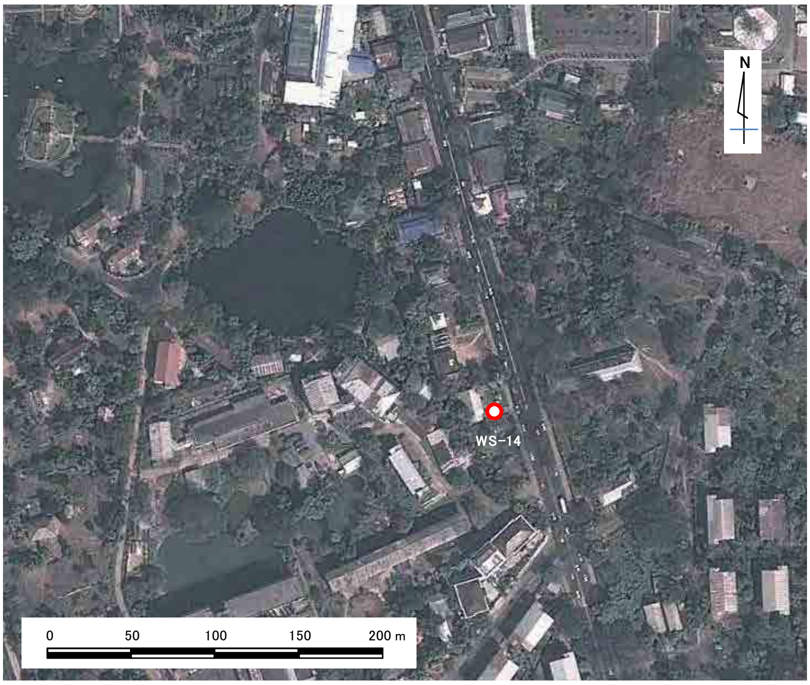
Sampling Point WS - 4 and WS - 11

Sampling Point WS - 7 and WS - 12

Sampling Point WS - 8 and WS - 13

Sampling Point WS - 9

Sampling Point WS - 10



Sampling Point WS - 14

Sampling Point WS - 15

3. TAP WATER QUALITY INVESTIGATION

Purpose of this investigation is to understand the tap water quality of chlorinated water in Yegu P/S water distribution area.

Sampling was done in Yegu P/S, Yankin T/S, Kokine S/R, Dagon T/S, Pabedan T/S, Latha T/S, Lanmadaw T/S, Sanchaung T/S, Ahlone T/S and Kyimyindaing T/S. Analysis item is Air temperature, Water temperature, pH, EC, Turbidity, Free chlorine, Total coliforms and Fecal coliforms

Yegu P/S water distribution network is shown below, and obtained water quality is shown in Table C.11 and C.12.

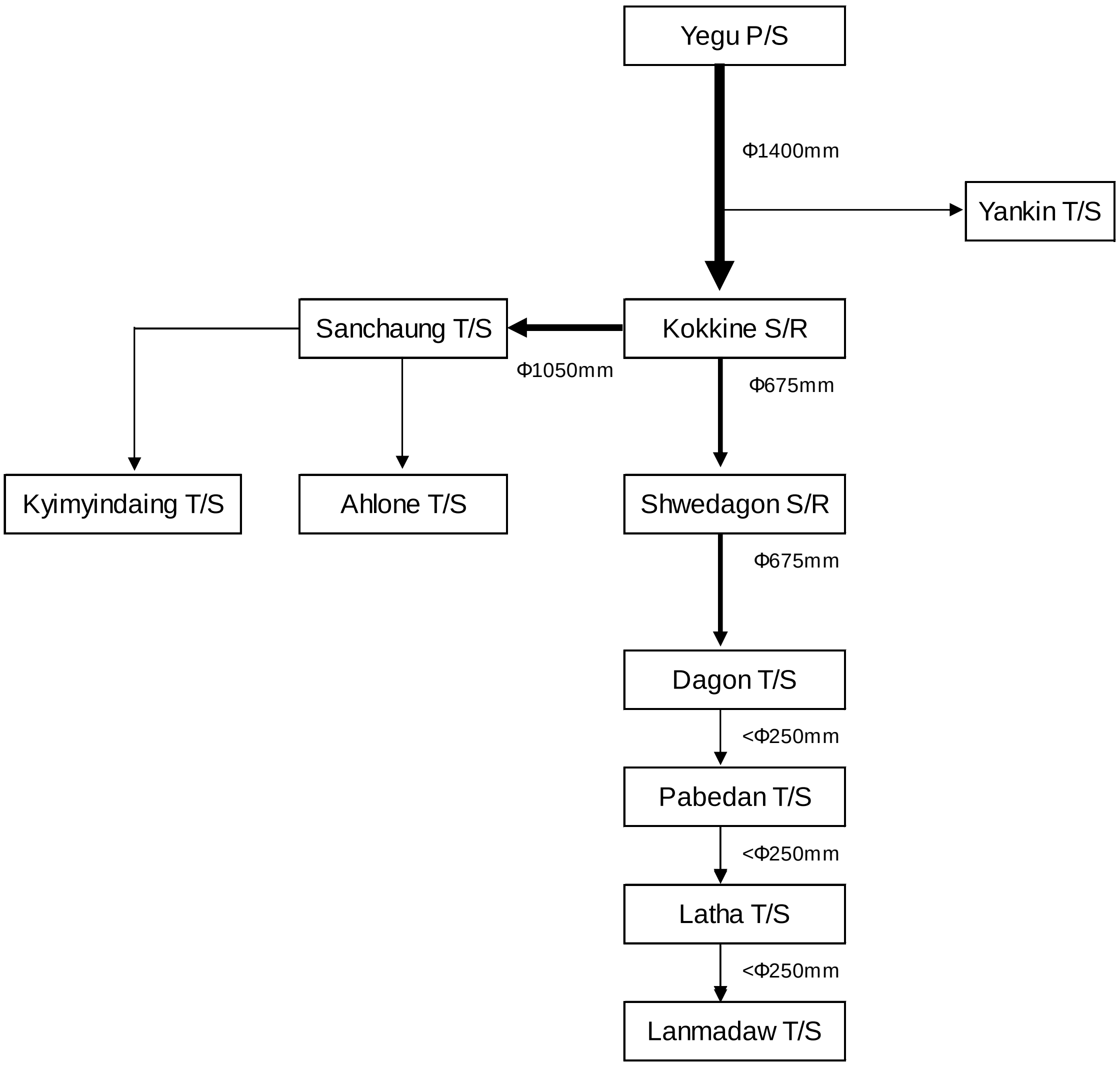


Figure C.2 Water Distribution Network of Yegu P/S

Table C.11 Water Quality of Tap Water Part 1 Sampling Date: April 3, 2013

Sampling point	Time	Air Temp. (℃)	Water Temp. (℃)	pH	EC (µS/cm)	Turbidity (NTU)	Free chlorine (mg/L)	Total coliforms	Fecal coli
Yegu P/S	10:55	32.0	30.5	7.39	80	4.64	0.21	Detected	Detected
Yankin T/S	11:55	34.2	30.0	7.27	90	9.63	0.17	Detected	Detected
Kokine S/R	12:30	34.1	34.0	7.45	80	4.12	0.21	Detected	Detected
Dagon T/S	13:15	34.9	31.0	7.34	90	7.07	0.25	Detected	Detected
Pabedan T/S	14:34	34.0	28.9	7.36	50	1.85	0.11	Detected	Detected
Latha T/S	15:07	36.5	30.2	6.25	130	1.24	0.10	Detected	Detected
Lanmadaw T/S	15:35	34.9	32.0	6.40	110	1.28	0.04	Detected	Detected

Table C.12 Water Quality of Tap Water Part 2 Sampling Date: May 5, 2013

Sampling point	Time	Air Temp. (℃)	Water Temp. (℃)	pH	EC (µS/cm)	Turbidity (NTU)	Free chlorine (mg/L)	Total coliforms	Fecal coli
Yegu P/S	9:35	32.0	30.8	7.00	80	2.83	0.18	Detected	Detected
Kokine S/R	8:55	30.5	30.5	6.86	90	0.88	0.22	Detected	Detected
Sanchaung T/S	7:27	29.0	30.5	7.43	90	2.95	0.14	Detected	Detected
Ahlone T/S	8:30	30.5	31.0	5.25	40	0.09	0.00	Detected	Detected
Kyimyindaing T/S	8:00	30.0	30.3	6.94	80	2.10	0.14	Detected	Detected

Change of water quality is shown below;

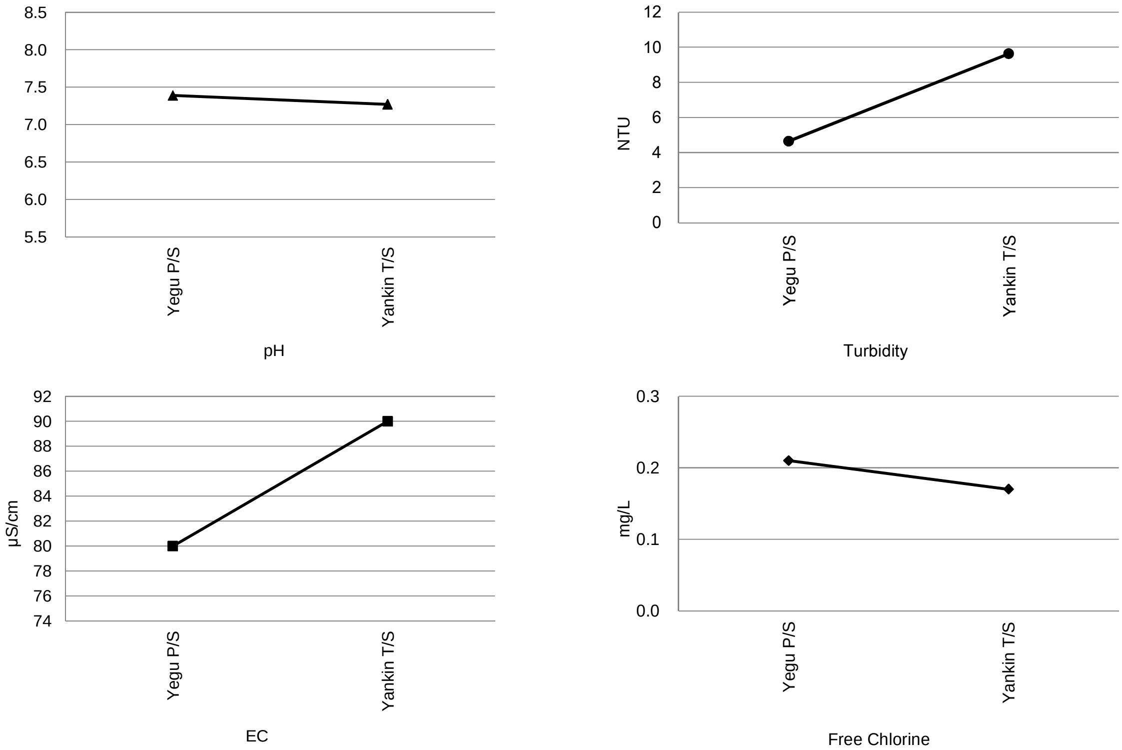


Figure C.3 Change of Water Quality (1)

Yegu P/S >> Yankin T/S

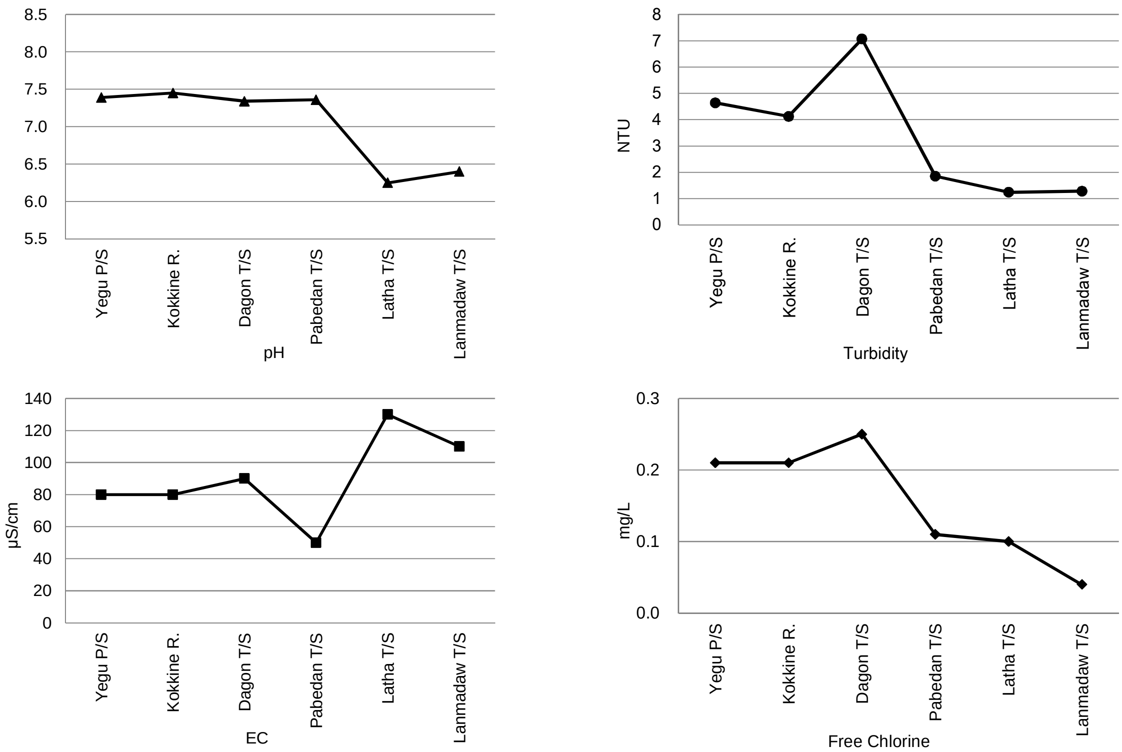


Figure C.4 Change of Water Quality (2)

Yegu P/S >> Kokine R. >> Dagon T/S >> Pabedan T/S >> Latha T/S >> Lanmadaw T/S

Survey Part2: May, 2013

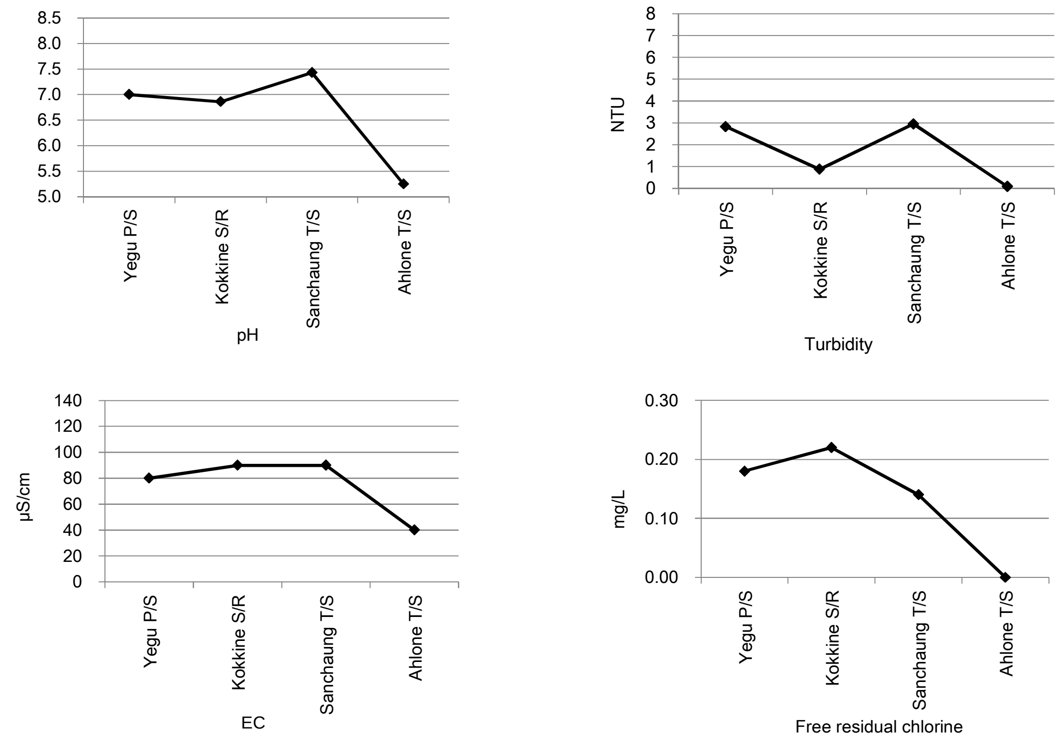


Figure C.5 Change of Water Quality: Yegu P/S - Kokine S/R - Sanchaung T/S - Ahlone T/S

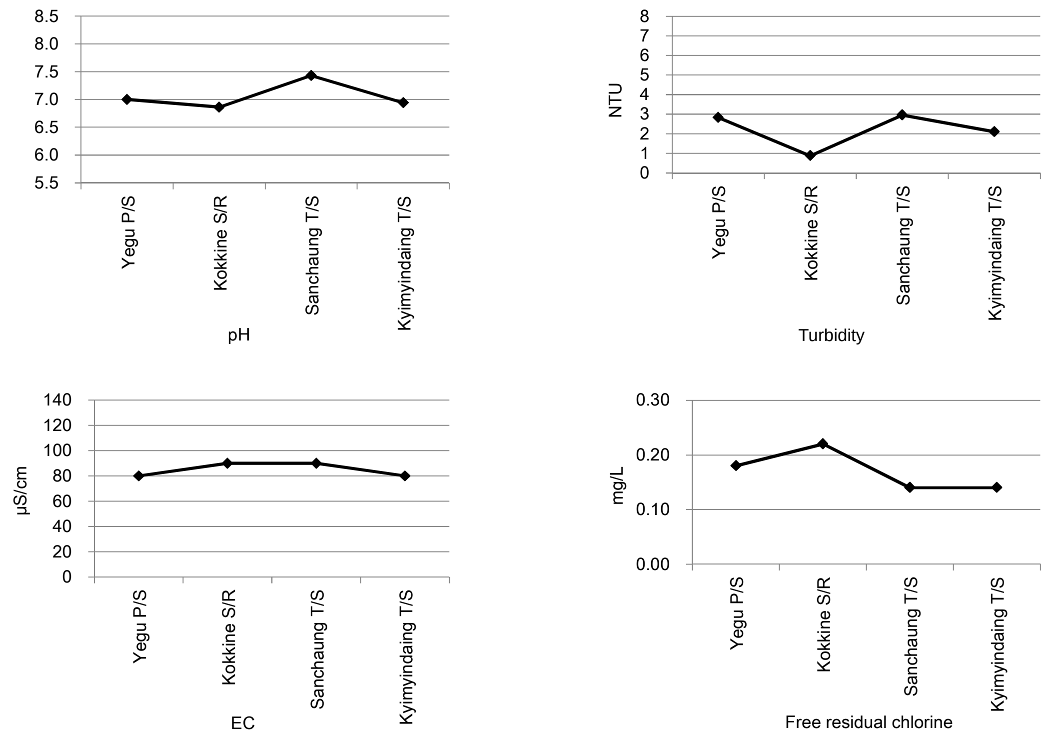


Figure C.6 Change of Water Quality:

Yegu P/S - Kokine S/R - Sanchaung T/S - Kymiyindaing T/S

Survey Part1: March 2013

At first, Increase of EC and Turbidity, and decrease of free chlorine was observed in Yegu P/S - Yankin T/S. Possible reason of this water quality change is as follows;

- Treated water is polluted by wastewater intrusion into water transmission pipeline from Yegu P/S to Yankin T/S or water distribution network in Yankin T/S.
- Wastewater intrusion may be occurred by disrepair of distribution network or inadequate pipework.

Similarly, increasing of EC and decrease of free chlorine was observed in Dagon T/S – Pabedan T/S – Latha T/S. Possible reason of this water quality change is as same as above mentioned.

On the other hand, acute decrease of Turbidity was observed in Dagon T/S – Pabedan T/S. Possible reason of this water quality change is that deposition of turbidity is occurred in distribution network because of the low pressure and low flow velocity in distribution network.

Local residence in Pabedan T/S, Latha T/S and Lanmadaw T/S said that tap water pressure is very low, and they usually use suction pump to obtain tap water. In every daytime of March and April, Yangon City is challenged by electric outrage. During electric outrage, all suction pump are suspended, and water flow in distribution network may stop. That is, it is assumed that the decrease of turbidity is occurred during this suction pump suspended period.

Total coliforms and fecal coliforms were detected from all samples. In this survey period, chlorinator in Yegu P/S was working. Therefore, it is assumed that water distribution network is already polluted seriously, or the ability of chlorinator (injection ratio) is not enough.

Survey Part2: May 2013

In the survey area (i.e. Sanchaung T/, Kyimyindaing T/S and Ahlone T/S), intermitted water supply (from 7:00 – 9:00) is implemented, and well water is utilized in other period of time. Therefore, survey was done within water supply period (from 7:00 to 9:00)

In Yegu P/S – Kokine S/R – Yegu P/S – Kokine S/R – Sanchaung T/S – Kyimyindaing T/S, water quality did not change drastically except decreasing of turbidity in Kokine S/R.
On the other hand, decreasing of pH, EC, Turbidity and Residual chlorine was observed in SanchaungT/S – Ahlone T/S.

Ahlone T/S is a terminal part of Yegu P/S water distribution network, and many shallow well are connected to water distribution network to compensate inadequate water quantity and pressure. Therefore, possible explanations of this change of water quality will be an influence of well water.

Total coliforms and fecal coliforms were detected from all samples.

4. Characteristics of water treatment in WTP

Characteristics of water WTP is considered. Summary of Nyaunghnapin WTP, Thaephyu WTP and South Dagon No.2 WTP is as follows;

Table C.13 Characteristic of WTP

Name of WTP	Capacity (m^3/day)	Water source	Treatment method
Nyaunghnapin	204,500	Ngamoeyeik R	Coagulation and sedimentation Rapid sand filter
Thaephyu	4,500	Tube well	Cascade aeration system Up flow sand filter
South Dagon No.2	4,500	Tube well	Cascade aeration system Up flow sand filter

<u>Nyaunghnapin WTP</u>

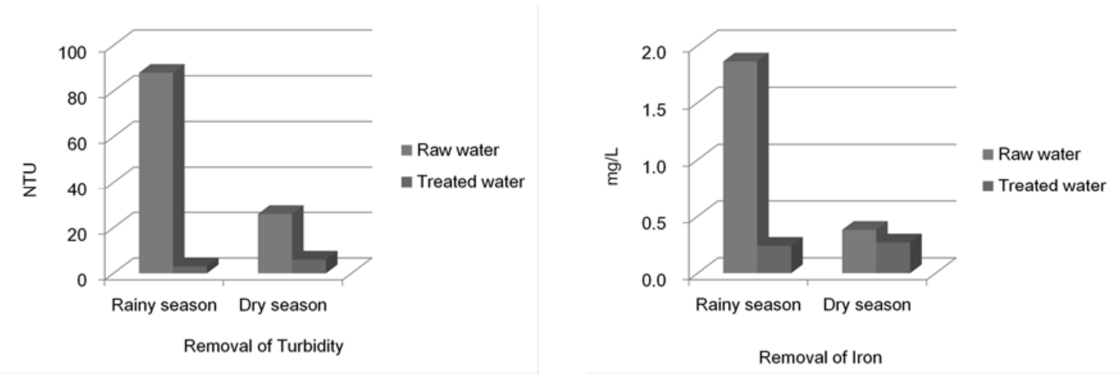


Figure C.7 Removal of Turbidity and Iron in Nyaunghnapin WTP

In raw water, turbidity and iron in rainy season are higher than those of dry season. However, both turbidity and iron are removed by water treatment process.

In dry season, iron (0.33 mg/L) exceeds highest desirable level of Myanmar (0.3mg/L)

<u>Thaephyu WTP</u>

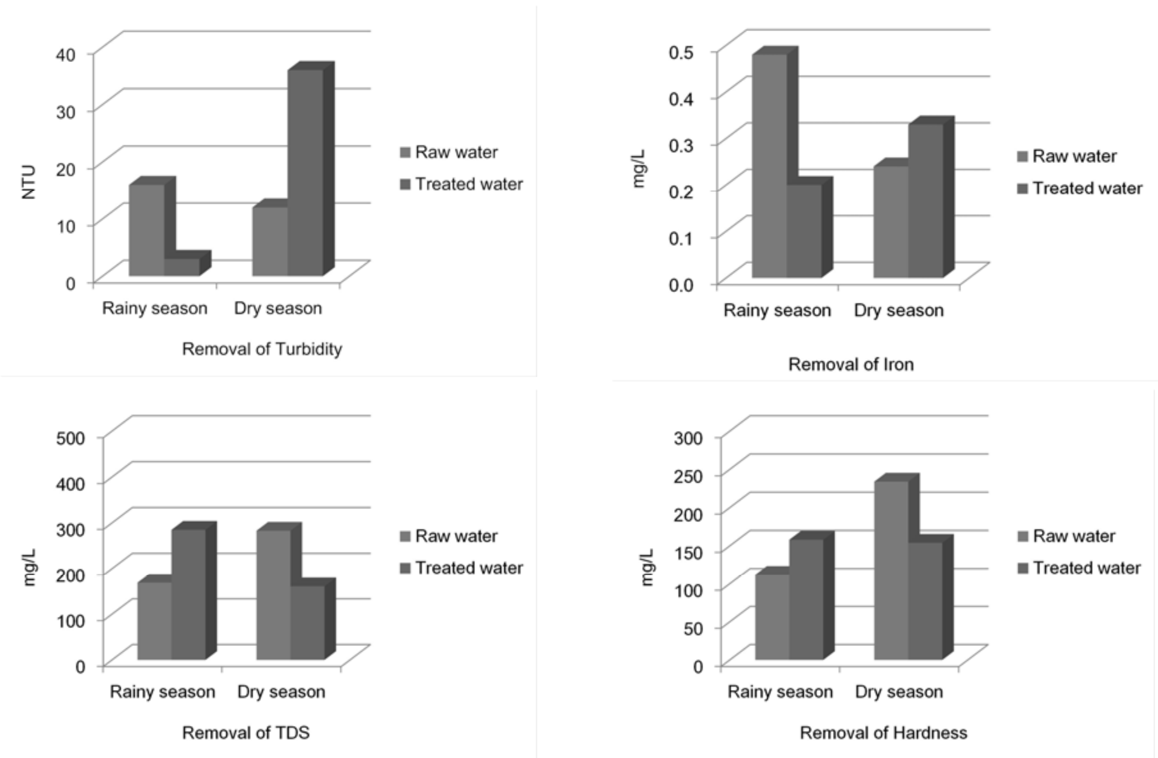


Figure C.8 Removal of Turbidity, Iron, TDS and Hardness in Thaephyu WTP

Increasing of turbidity and iron of treated water were observed in dry season. This deterioration of water quality may be caused by an insufficient management of treatment facility, especially, insufficient cleaning of up flow sand filter.

Both TDS and hardness were not removed by water treatment process of this WTP, however, concentration of them in treated water is lower than maximum permissible level of Myanmar.

<u>South Dagon No.2 WTP</u>

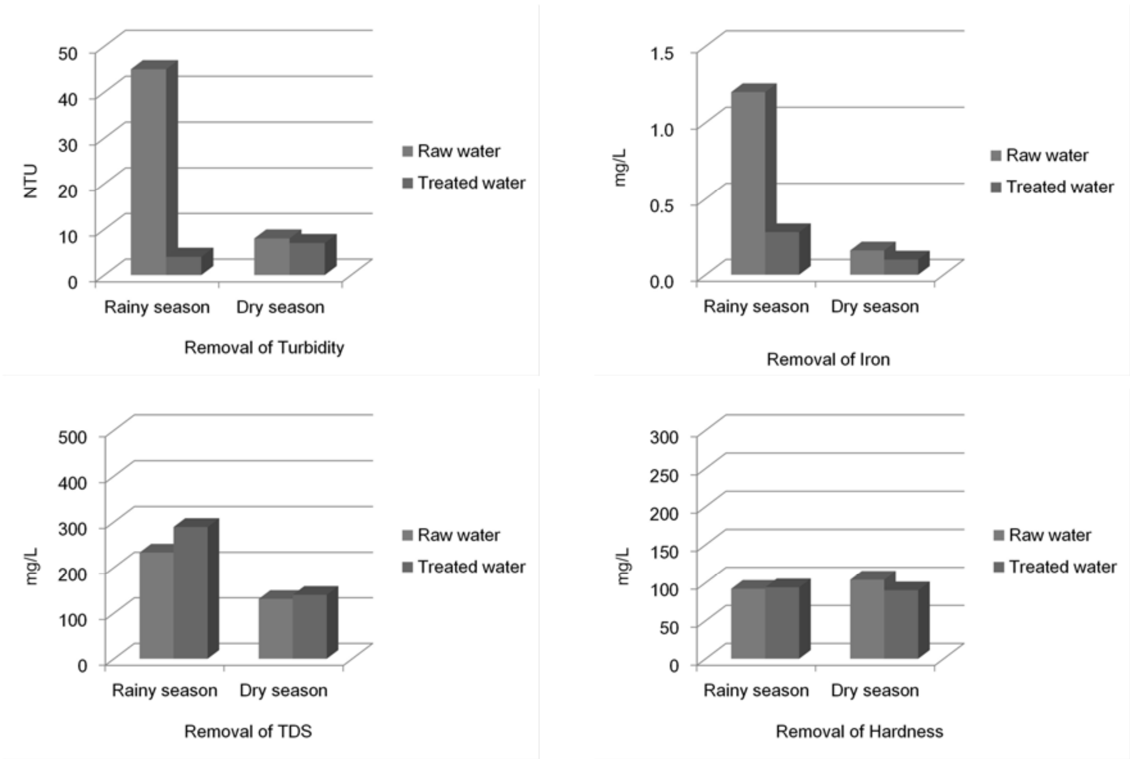


Figure C.9 Removal of Turbidity, Iron, TDS and Hardness in South Dagon No.2 WTP

In rainy season, turbidity and iron were higher than those of dry season. Possible reason of this difference is the outflow of contamination in deep well due to the elevation of groundwater level.
However, turbidity and iron are removed by treatment process in this WTP. Both turbidity and iron satisfy Maximum permissible level of Myanmar.

Both TDS and hardness were not removed by water treatment process of this WTP, however, concentration of them in treated water is lower than maximum permissible level of Myanmar.

Total coliform group and fecal coli were detected from treated water of Nyaunghnapin WTP, Thaephyu WTP and South Dagon No.2 WTP.
Implement of adequate management of WTP facility and apply of chlorination is necessary.

5. SALTWATER INVASION SURVEY

To decide water intake facility construction site in Toe River and Kokkowa River, salinity water invasion survey was done in the high tide period and low tide period in March, 2013.

5.1 Sampling and analysis method

(1) Analysis item

- TDS
- Chloride
- EC

(2) Assessment guideline of the effect of saltwater (see Reference)

When TDS or Chloride exceed following level, drinking-water becomes significantly and increasingly unpalatable.

Therefore, in this investigation, assessment criteria of the effect of salt water intrusion are decided as follows;

- TDS: < 500 mg/L (0.5g/L = 0.5 ppt)
- Chloride: < 250mg/L

(3) Analysis

Water sample analysis is done as below;

- TDS: On site measurement using portable analyzer
- Chloride: On site measurement using simple test method and laboratory analysis
- EC: On site measurement using portable analyzer

5.2 Toe River

Saltwater intrusion survey in Toe River was done on a day during high tide period (15 March) and low tide period (18 March).

(1) Salt water intrusion survey (high tide)

<u>Sampling point</u>

Survey was done on 15 March, 2013. 5 sampling points were decided. Sampling was done from downstream to upstream. Detailed information of sampling point is described in the following table.

Table C.14 Summary of Sampling Point (Toe River, High Tide, Part1)

Sampling point	Distance from Water intake	Number of sample
Toe river Upper stream 2	4.6 km	Surface layer water and Lower layer (about 5m below the water surface, same as above) water samples were collected Total: 2 samples
Toe river Upper stream 1	2.5 km	Surface layer water and Lower layer water samples were collected Total: 2 samples
Toe river Water intake point	---	3 sampling points are decided along the cross section. For each sampling point, Surface layer and Lower layer water samples were collected. Total: 6 samples
Toe river Downstream 2	3.9 km	Surface layer water and Lower layer water samples were collected Total: 2 samples
Toe river Downstream 1	7.8 km	Surface layer water and Lower layer water samples were collected Total: 2 samples

Note: Sampling depth: Surface=surface of water, Lower: 5-6m depth of water

<u>Analysis item</u>

Analyzed items are as follows;

Water temp, pH, EC, TDS, Chloride

pH, EC and TDS were measured using HANNA combo water meter. Chloride analysis in this paper was done using simple assay. At present, chloride analysis of same 14 samples is done by ISO-Tech.

<u>Sampling point</u>

Overall view of sampling point is shown below.

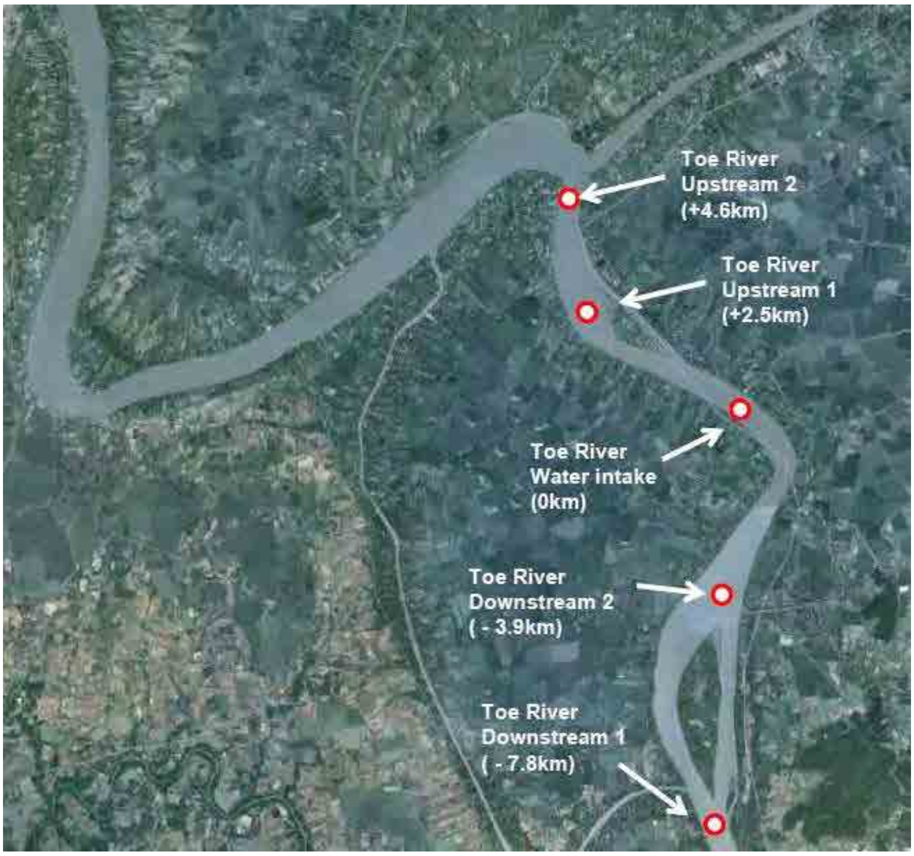


Figure C.10 Location of Sampling Point (Toe River, High Tide, Part1)

3 sampling point was decided on the cross section near water intake point. Actual sampling point and distance of each sampling point are shown in figure below.

Figure C.11 Location of Sampling Point, Near Water Intake Facility Construction Point (Toe River, High Tide, Part1)

Result of Saltwater intrusion survey

Result of analysis is shown below.

Table C.15 Result of Survey (Toe River, High Tide, Part1)

Sampling point		Time	Water Temp (°C)	pH	EC (mS/cm)	TDS (ppt)	Chloride (Approx.) (mg/L)
Toe River Upstream 2	Surface	18:05	28.5	8.42	0.22	0.11	≤100
	Lower	18:10	28.5	8.42	0.23	0.11	≤100
Toe River Upstream 1	Surface	17:51	28.8	8.37	0.30	0.15	≤100
	Lower	17:53	28.8	8.38	0.31	0.15	150
Toe River Water intake (Left)	Surface	17:16	29.3	8.31	0.45	0.22	250
	Lower	17:21	29.3	8.31	0.45	0.22	250
Toe River Water intake (Center)	Surface	17:29	29.5	8.31	0.51	0.26	≤100
	Lower	17:32	29.5	8.33	0.52	0.26	200
Toe River Water intake (Right)	Surface	17:38	28.5	8.32	0.46	0.24	200
	Lower	17:41	28.7	8.37	0.49	0.24	200
Toe River Downstream 2	Surface	16.50	29.9	8.29	0.54	0.27	150
	Lower	16:55	29.6	8.29	0.58	0.29	250
Toe River Downstream 1	Surface	16:35	30.8	8.32	0.49	0.25	≤100
	Lower	16:40	29.8	8.33	0.50	0.25	≤100

Note: This Chloride value is measured using simple assay. At present, chloride analysis is done by ISO-Tech.

In this survey, following analysis item and value are decided as assessment criteria.

- TDS: < 500 mg/L (0.5g/L = 0.5 ppt)
- Chloride: < 250mg/L

The samples of Water intake (Left) and Downstream 2 show 250mg/L (approx.) of Chloride. Therefore, water intake construction site have to be reassessed.

(2) Saltwater intrusion survey (Low tide)

Sampling point and sampling date

Survey was done on 18 March, 2013. 1 sampling point (cross section) was decided. Location of sampling point is shown below. Sampling point is 5.6 km downstream of Toe River Downstream 1. Therefore, distance from water intake point is 13.4 km. At the decided location, along cross section, 3 sampling point, i.e. Left bank, Center and Right bank were decided. Detailed sampling points are shown in the following map.

For each sampling point, 1 sample, i.e. Lower layer water (about 5m below the water surface) was collected.

Figure C.12 Location of Sampling Point (Toe River, Low Tide)

Figure C.13 Detailed Location of Sampling Point (Toe River, Low Tide)

Analyzed items and analysis method are same as mentioned above (i.e. Water temp, pH, EC, TDS, and Chloride)

Result of this survey

Result of analysis is shown below.

Table C.16 Result of Survey (Toe River, Low Tide)

Sampling point	Time	Water Temp (°C)	pH	EC (mS/cm)	TDS (ppt)	Chloride (Approx.)* (mg/L)
Left side	16:28	30.0	8.20	0.52	0.31	200
Center	16:24	30.0	8.30	0.53	0.27	200
Right side	16:20	30.0	8.48	0.62	0.25	200

(3) Toe River Saltwater intrusion survey (Part 2)

To clarify the extent of the impact of saltwater intrusion and reconsider a water intake construction site on Toe River, Saltwater intrusion survey in Toe River (Part2) was done at high tide period (29 March).

Sampling point and sampling date

Survey was done on 29 March, 2013.

5 sampling points were decided in Toe River (No.3, No.4 and No.5) and Twantay Canal (No.1 and No.2). Number of sampling at each sampling point is as follows;

Table C.17 Summary of Sampling Point (Toe River, High Tide, Part2)

Sampling point	Distance from Diversion point of Toe River and Twantay Canal	Number of sample
No. 1	8.2 km 1.2 km from Twantey Town River Port	Surface layer water and Lower layer (about 5m below the water surface) water samples were collected Total: 2 samples
No. 2	0.5 km	Surface layer water and Lower layer water samples were collected Total: 2 samples
No. 3	1.5 km	3 sampling point are decided along the cross section. For each sampling point, Surface layer and Lower layer water samples were collected. Total: 6 samples
No. 4	4.7 km	Surface layer water and Lower layer water samples were collected Total: 2 samples
No. 5	9.2 km	Surface layer water and Lower layer water samples were collected Total: 2 samples

Note: Sampling depth: Surface=surface of water, Lower: 5-6m depth of water

Analyzed items and analysis method are same as mentioned above (i.e. Water temp, pH, EC, TDS, and Chloride)

<u>Sampling point</u>

Overall view of sampling points is shown below;

Figure C.14 Location of Sampling Point (Toe River, High Tide, Part2)

In this survey, cross section sampling (3 sampling points along the cross section) was done at location No.3. Actual sampling points and distance of No. 3 sampling point is shown below;

Figure C.15 Detail of Sampling Point No.3 (Toe River, High Tide, Part2)

<u>Result of this survey</u>

Result of this survey is shown below.

Table C.18 Result of Survey (Toe River, High Tide, Part2)

Sampling point		Time	Water Temp (°C)	pH	EC (mS/cm)	TDS (ppt)	Chloride (Approx.) (mg/L)
No. 1	Surface	17:05	29.9	8.22	0.53	0.26	150
	Lower	17:05	29.7	8.30	0.53	0.26	≤100
No. 2	Surface	16:10	29.9	8.40	0.23	0.11	≤100
	Lower	16:16	29.7	8.42	0.23	0.11	≤100
No. 3 (Left)	Surface	15:35	30.4	8.31	0.21	0.10	≤100
	Lower	15:39	30.0	8.37	0.21	0.11	≤100
No. 3 (Center)	Surface	15:42	29.9	8.41	0.22	0.11	≤100
	Lower	15:46	29.5	8.42	0.21	0.11	≤100
No. 3 (Right)	Surface	15:53	30.2	8.42	0.22	0.11	≤100
	Lower	15:56	29.7	8.41	0.22	0.10	≤100
No. 4	Surface	15:00	29.9	8.29	0.21	0.10	≤100
	Lower	15:00	29.6	8.43	0.23	0.11	≤100
No. 5	Surface	14:33	29.6	8.32	0.21	0.11	≤100
	Lower	14:40	29.8	8.41	0.22	0.11	≤100

From this survey, Toe River upstream (No. 3, No. 4 and No. 5) satisfy the assessment criteria. Therefore, Toe River upstream is a recommendable area for new water intake construction.

On the other hand, point No. 1 showed higher level of EC, TDS and Chloride. Considering the difference in Chloride concentration of surface and lower layer water of location No.1, this water quality change may be caused by the discharge of urban drainage of Twantey town.

(4) Conclusion of Toe River saltwater intrusion survey

Through these surveys, TDS value satisfies the assessment criteria in this survey (< 500mg/L).

However, Chloride was near assessment criteria level (<250mg/L) in the downstream of Toe River / Twantay Canal diversion point (200 mg/L (Low tide period) and 250mg/L (High tide period)). On the contrary, in the upstream of Toe River / Twantay Canal diversion point, Chloride was < 100mg/L in High tide period.

Considering the adverse effect of Chloride to tap water quality (offensive taste and odor), new water intake facility construction site in Toe River should be decided in the upstream of Toe River / Twantay Canal diversion point.

5.3 Kokkowa River Saltwater intrusion survey

Saltwater intrusion survey in Kokkowa River was done for high tide period (14 March) and low tide period (20 March).

(1) Saltwater intrusion survey (High tide)

<u>Sampling point and sampling date</u>

Survey was done on 14 March, 2013. 5 sampling points were decided. Sampling was done from downstream to upstream. Number of samples collected at each sampling point is as follows;

Table C.19 Summary of Sampling Point (Kokkowa River, High Tide)

Sampling point	Distance from Water intake	Number of sample
Kokkowa river Upper stream 2	4.7km	Surface layer water and Lower layer (about 5m below from water surface, same as above) water samples were collected Total: 2 samples
Kokkowa river Upper stream 1	3.3km	Surface layer water and Lower layer water samples were collected Total: 2 samples
Kokkowa river Water intake point	---	3 sampling points are decided along the cross section. For each sampling point, Surface layer and Lower layer water samples were collected. Total: 6 samples
Kokkowa river Downstream 2	5.5km	Surface layer water and Lower layer water samples were collected Total: 2 sample
Kokkowa river Downstream 1	8.3km	Surface layer water and Lower layer water samples were collected Total: 2 samples

Note: Sampling depth: Surface=surface of water, Lower: 5-6m depth of water

Analyzed items and analysis methods are same as mentioned above (i.e. Water temp, pH, EC, TDS, and Chloride)

<u>Sampling point</u>

Overall view of sampling points is shown below;

Figure C.16 Location of Sampling Point (Kokkowa River, High Tide)

In this survey, cross section sampling (3 sampling point along the cross section) was done near the Water intake point. Actual sampling point and distance of sampling point is shown below. To avoid other river traffic, sampling point on left side was shifted about 300m towards upstream.

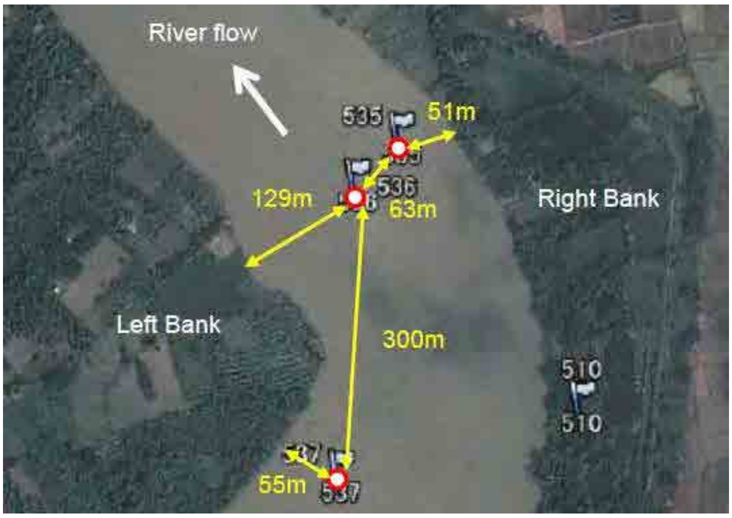


Figure C.17 Location of Sampling Point, Near Water Intake Facility Construction Point (Kokkowa River, High Tide)

Result of this survey

Result of analysis is shown below.

Table C.20 Result of Survey (Kokkowa River, High Tide)

Sampling point		Time	Water Temp (°C)	pH	EC (mS/cm)	TDS (ppt)	Chloride (Approx.) (mg/L)
Kokkowa River Upstream 2	Surface	18:43	27.0	8.45	0.21	0.11	≤100
	Lower	18:40	27.0	8.35	0.21	0.10	≤100
Kokkowa River Upstream 1	Surface	18:29	27.0	8.28	0.22	0.11	≤100
	Lower	18:33	27.0	8.34	0.21	0.11	≤100
Kokkowa River Water intake (Left)	Surface	18:07	28.1	8.22	0.21	0.11	≤100
	Lower	18:10	27.8	8.28	0.22	0.11	≤100
Kokkowa River Water intake (Center)	Surface	17:50	28.0	8.21	0.21	0.10	≤100
	Lower	17:46	28.0	8.30	0.22	0.11	≤100
Kokkowa River Water intake (Right)	Surface	17:43	29.5	8.21	0.21	0.10	≤100
	Lower	17:44	28.5	8.26	0.22	0.10	≤100
Kokkowa River Downstream 2	Surface	17:01	29.0	8.11	0.21	0.10	≤100
	Lower	17:15	29.0	8.24	0.22	0.11	≤100
Kokkowa River Downstream 1	Surface	16:40	28.8	8.16	0.21	0.11	≤100
	Lower	16:39	29.0	8.20	0.23	0.11	≤100

As shown in above table, water quality around planned water intake site satisfies the assessment criteria (See below).

- TDS: < 500 mg/L (0.5g/L = 0.5 ppt)
- Chloride: < 250mg/L

(2) Saltwater intrusion survey (Low tide)

Sampling date and sampling point

Survey was done on 20 March, 2013.

Location of sampling point is shown below. Sampling point is about 0.5 km upstream of Kokkowa River water intake site.

In this survey, 1 sampling point (cross section) was decided. At the location of the decided cross section, 3 sampling points, i.e. Left bank, Center and Right bank were decided. Detailed sampling point is shown below. Sampling was done for lower layer water (about 5m below from water surface). Analyzed items and analysis method are same as explained above (i.e. Water temp, pH, EC, TDS, and Chloride)

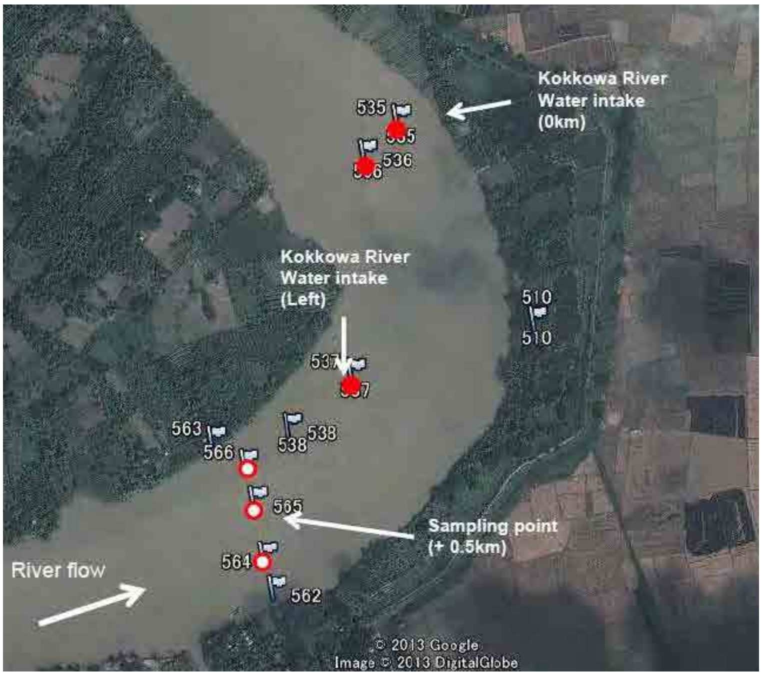


Figure C.18 Location of Sampling Point (Kokkowa River, Low Tide)

<u>Result of this survey</u>

Result of this survey is shown below.

Table C.21 Result of Survey (Kokkowa River, Low Tide)

Sampling point	Time	Water Temp (°C)	pH	EC (mS/cm)	TDS (ppt)	Chloride (Approx.) (mg/L)
Left side	7:02	29.0	8.34	0.23	0.11	≤100
Center	6:57	29.0	8.34	0.22	0.12	≤100
Right side	6:49	29.0	8.38	0.26	0.13	≤100

Similar to the case of high tide period, both TSD and Chloride satisfy following assessment criteria.

- TDS: < 500 mg/L (0.5g/L = 0.5 ppt)
- Chloride: < 250mg/L

This survey is done as a background survey of salt water intrusion. Obtained result shows that water quality of planned water intake site satisfies the assessment criteria.

(3) Conclusion

Through these 2 surveys on Kokkowa River, water quality (TDS and Chloride) around water intake construction site satisfy the assessment criteria. Therefore, from the view of water quality, this location is recommendable as new water intake construction site.

Appendix 1: Background of assessment criteria in this survey

Source: WHO drinking water safety guideline, 4^{th} edition

TDS

The palatability of water with a total dissolved solids (TDS) level of less than about 600 mg/L is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/L. The presence of high levels of TDS may also be objectionable to consumers, owing to excessive scaling in water pipes, heaters, boilers and household appliances.

Chloride

High concentrations of chloride give a salty taste to water and beverages. Taste thresholds for the chloride anion depend on the associated cation and are in the range of 200–300 mg/L for sodium, potassium and calcium chloride. Concentrations in excess of 250 mg/L are increasingly likely to be detected by taste, but some consumers may become accustomed to low levels of chloride-induced taste.

D. BASIS OF FACILITIES DESIGN

(1) Intake and water conveyance facilities

Intake facilities from surface water are assumed in this section. An intake gate for drawing water from surface water, an open channel for water conveyance, a settling basin for reducing high turbidity raw water, etc. are adopted as intake facilities. It is expected that raw water of high turbidity flows into grit chamber, and mud sediments and accumulates at the bottom. Since it is assumed that regular dredging of grit chamber is indispensable, preparation of small excavator is planned. Two or more grit chambers are set and dual-system is adopted, and a sand pit is setup on chamber bottom and drainage by a sand pump is adopted. In addition, for protection of intake pump, automatic screen equipment is installed in grit chamber.

〇Settling basin and grit chamber: dual-system, capacity; 3 days or more (for turbidity reduction), Leaning type retaining wall, baffle walls for short circuit flow prevention
〇O&M equipment
Automatic screen equipment
Small excavator
Sand pumps
〇Intake trough
Water gauge: electrode/ pressure type
〇Intake pump
Intake pump building: RC
Intake pumps: pump heads; about 10 m
〇Measurement equipment
Flow meter (inlet): electromagnetic type

(2) Water Treatment Plant (WTP)

The ”Coagulation, Sedimentation, Rapid sand filtration” system is adopted in case of new-WTP similar to the existing Nyaunghnapin WTP. The existing filtration basins have dual-media filter of anthracite/sand, backwashing speeds have been rapid, and therefore filter media escapes out and the depth of filter beds gets thinner gradually. Single media sand type is recommended for filtration basins considering the present O&M level. In addition, a self-backwashing type and surface washing type is recommended from the viewpoint of energy saving.

〇Receiving well: dual-system, capacity; 10 minutes or more
〇Flocculation basin: dual-system, baffled channel mixing
〇Sedimentation basin: horizontal-flow type, inlet flow uniforming wall x 1row + middle flow uniforming wall x 1row + in front of an outlet trough flow uniforming wall x 1row

○Drainage valve: motor-operated eccentric valve + timer type control board
○Rapid sand filtration: dual-system, self-backwashing type filter
Filtration rate; 120-150 m/day, as Japanese standard
Inlet flow/ outlet flow/ drainage valve; motor-operated valve
Surface washing type; the same as existing system of Nyaunghnapin WTP
Backwashing pump: 1 unit duty + 1 unit stand-by
Surface washing pump: 1 unit duty + 1 unit stand-by
Filter media: single media river-sand, uniformity coefficient; 1.70 or less, sand layer thickness; 60-70cm, as in Japanese standard
Level gauge: electrode/ pressure type
○Treated water reservoir: dual-system, capacity of reservoir will be 1.25 hours in order to serve as pumping well.
Level gauge: electrode/ pressure type

○Water quality monitor equipment
Raw water: turbidity/ pH
After sedimentation water: turbidity/ pH
Treated water: turbidity/ pH/ residual chlorine

(3) Chemical feeding equipment

Coagulant feeding equipment is installed as chemical feeding equipment, and installation of a coagulation aid feeding equipment is considered if needed. Since liquid polyaluminum chloride (PAC) is used as coagulant in the existing system, the same coagulant is adopted, and storage tanks and feeding pumps are installed.

○Coagulant feeding equipment
Coagulant: liquid polyaluminum chloride (PAC), coagulant dosage; 40-80mg/L as temporary standard (coagulant dosage should be reconfirmed by the water quality test)

○Coagulation aid feeding equipment
Alkali agent: hydrated lime, coagulant dosage; 10-30mg/L as temporary standard (coagulant dosage should be reconfirmed by the water quality test)

(4) Disinfection equipment

Intermediate chlorination: liquid sodium hypochlorite, chlorine dosage: 1mg/L as temporary standard (chlorine dosage should be reconfirmed by the water quality test)
Post-chlorination: liquid sodium hypochlorite, chlorine dosage: 1-5mg/L as temporary standard (chlorine dosage should be reconfirmed by the water quality test)

(5) Wastewater treatment system

Gravity concentration equipment and sludge drying bed are adopted as wastewater treatment system.

〇Wastewater treatment facility

Wash water drainage basin: dual-system, RC, from filtration backwashing drainage, sludge withdrawal pump; 1 unit duty + 1 unit stand-by

Sludge basin: dual-system, circular RC type, from sedimentation sludge, sludge withdrawal pump; 1 unit duty + 1 unit stand-by

Sludge thickener: dual-system, circular RC type, sludge withdrawal pump; 1 unit duty + 1 unit stand-by

Sludge drying beds

(6) Transmission Facilities

Since long-distance pumping is assumed as transmission facilities, surge tank or check valve buffering surge is added to pump equipment. In addition, bulk meter, level gauge, motor operated valve on discharge side, etc. are installed. A reserve machine is secured for M&E equipment and it is considered for achievement of stable running.

〇Pumping well; including in treated water reservoir

〇Transmission pump storing building: RC

Level gauge: electrode/ pressure type

Bulk meter (outlet): electromagnetic type

〇Transmission pump: maximum pump head of 90m (hydrostatic pressure resistance 0.1MPa as pipe)
Maximum motor output 800kw (The maximum size treated by YCDC)

The measure against water hammer: surge tank and/or check valve

The number of pumps to be installed is decided considering synchronized operation of intake pump and transmission pump.

(7) Electrical equipment

The electrical equipment system in which breaker boards are intensively installed in one new electricity room is recommended. In addition, a breaker panel with communication interface corresponding to remote control and a monitor (automatic control panel or SCADA, etc.) is recommended. A SCADA system is installed in the central monitor room.

A pit with a lid or ceiling wiring in a cable tray is adopted as a cable route in order to prevent erroneous contact. In addition, a cable from the pit/tray to an electric motor terminal box passes through inside of a protective tube, and those outer skins will be designed so that it may be hidden.

〇Electrical room (Receiving panel, transformer panel, etc.)

〇Generator equipment: Electricity requirement of intake pumps, transmission pumps, chemical feeding equipment are covered.

(8) O&M facilities etc.

A central administration building, a warehouse, a workshop, and an exterior road, etc. required for O&M as other facilities are arranged.

〇Central administration building

Central control room: with SACDA, uninterruptible power supply (UPS)

〇Water testing laboratory: Room size in which at least the jar test can be carried out

〇Exterior water supply: A pump unit is supplied from treated water reservoir

〇Warehouse: For storage of chemicals

〇Workshop: For pump repair

〇Parking lot

〇Guard man room

〇Exterior road: Asphalt paving + green belt

〇Exterior fence: steel type

(9) Route of transmission pipe

Since the transmission pipe is of large diameter, as for the pipeline route, a wide road is chosen mostly. The route was selected by the study team in collaboration with the YCDC based on the following policies. In planned implementation, site acquisition for these routes or negotiation with a road administrator is needed.

(Route selection policy)

・A route used as the shortest distance from WTP to S/R

・A route in which traffic concentrates is avoided if possible

・As for crossing of a wide river, dual-system is adopted so that it can respond to future O&M/accident

・A pipe is arranged in loop form so that it can respond to future O&M/accident

The polyethylene pipe (PE) is used as transmission pipe in Nyaunghnapin Phase-2. In the suburbs, a pipeline generally is laid in vacant lot of a road outer side, and a part of pipeline is exposed. On the other hand, on a road with much traffic in the city, since there are few vacant lots beside the road, a pipeline is laid under roadbed. In such cases, in order to withstand traffic load repeatedly, pipe material having high strength/reliability is required. For this case, neither PE that is weak to ultraviolet rays nor FRP which is weak against any shock is recommended. A steel pipe (SP) and ductile cast iron pipe

(DIP) that are excellent in durability are recommended for such situation.

〇Material of pipe: DIP(φ200～φ600), SP (φ700～)

(10) Service Reservoir (S/R)

S/R adjusts an amount of treated water sent from WTP and distributed water to in the city. Water used in an area has a diurnal fluctuation and normally the peak demand occurs in the morning and evening. S/Rs are required to cater to this variation in demand/uses and generally its capacity is equivalent to 8 hours water demand.

〇Distribution Facilities

Service Reservoir: dual-system, baffle walls
Distribution pump building: RC
Level gauge: electrode/ pressure type
Bulk meter (inlet/outlet): electromagnetic type

(11) Distribution pump

As a measure against water hammer, flywheel or check valve buffering surge is added to pump equipment. In addition, bulk meter, level gauge, motor operated valve at discharge side, etc. are installed. A reserve machine is secured for M&E equipment and it is considered for achievement of stable running.

〇Distribution pump: maximum pump head 90m (hydrostatic pressure resistance 0.1MPa as pipe)

Maximum motor output 800kw (The maximum size treated by YCDC)
The measure against water hammer: flywheel and/or check valve

＜Required area＞

Required area is calculated by the following steps.

(a) Area of water surface: water supply amount÷3 (8 hours /24 hours)÷assumed depth 5m
Transmission amount÷24 (1hour/24 hours)÷assumed depth 5m is added in case of use of a relay pump.
(b) Distribution pump building: 20m×5m×planned pump number
(c) Area for O&M: Concrete 0.5 m in thickness of S/R frame, and 5 m in width of an exterior road are added to (a) + (b)

(12) DMA

The service population of each zone is calculated so that one DMA may serve a total of about 4,200 connections.

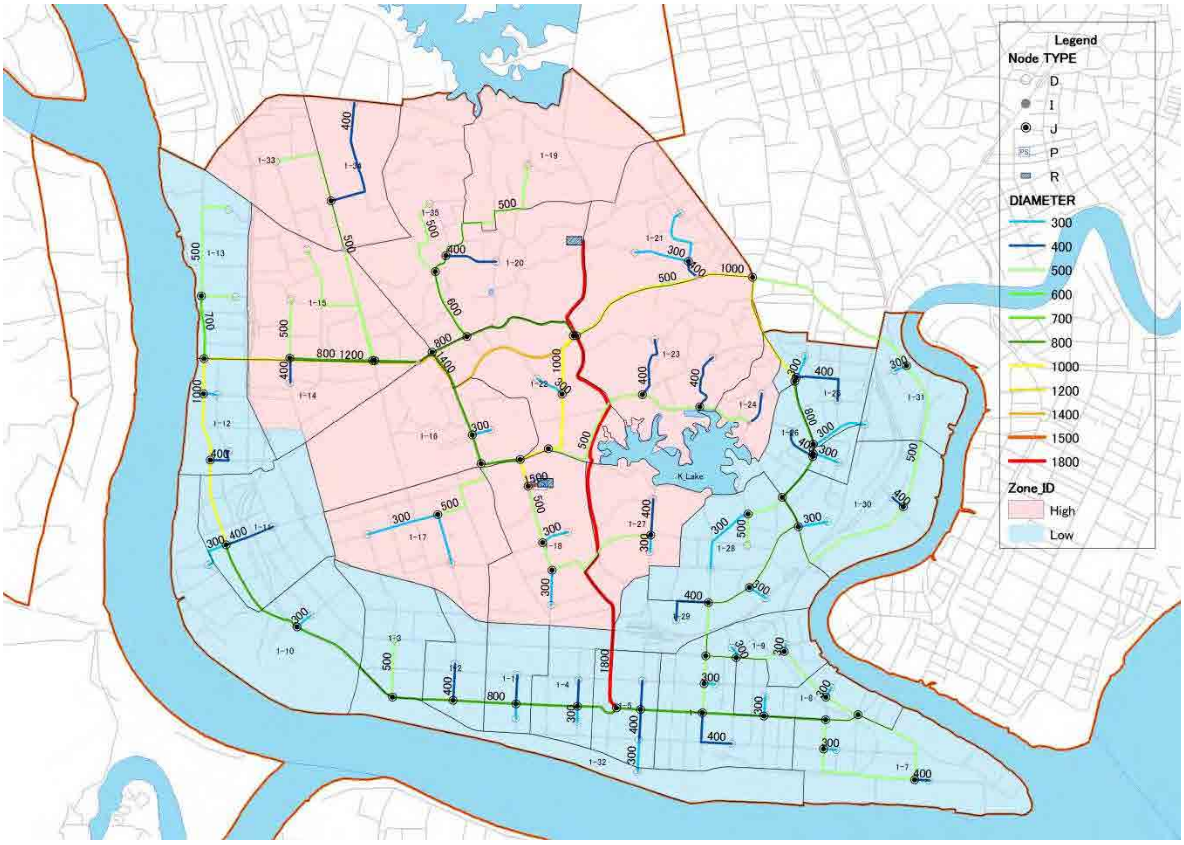
Total connection number =service population/6.3 person
A DMA= about 4,200 connections

(13) Route of distribution main pipe

In planned implementation, site acquisition for these routes or negotiation with a road administrator is needed.
For deciding distribution main pipe route, following key points are considered:
・A route that has the shortest distance from S/R to DMAs
・A route in which traffic concentrates is avoided if possible
・A pipe is arranged in loop form so that it can respond to future O&M/accident

SP or DIP excellent in durability is recommended in case of large diameter pipe for the same reason as in case of transmission pipe. PVC which YCDC is mainly using is adopted in case of a small diameter pipe.

〇Material of pipe: PVC(φ75～φ150), DIP(φ200～φ600), SP (φ700～)



Source: JICA Study Team

Figure D.1 Plan of DMAs and Route of Distribution Main Pipes (Zone 1)

(14) Calculation result

The calculation result for new pipelines and pumps are attached from the next page.

Facilities Planning for M/P by 2040 — 2013/4/29

10 Gyobyu Reservoir

Intake		Intake Pump		Gyobyu WTP		Transmission Pump	
Q(MGD)=	27	Q(m3/min)=	47.0	Q(MGD)=	27	Q(m3/min)=	42.7
m3/d	122,800	N =	2+(1)	m3/d	122,800	N =	2+(1)
HWL(m)=	+ 65.5	H (m)=	25.0	HWL(m)=	+ 57.6	H (m)=	47.0
LWL(m)=	+ 42.1	P (KW)=	280	LWL(m)=	+ 51.5	P (KW)=	500
GL (m)=	+ ???	GL (m)=	???	GL (m)=	???	GL (m)=	???

SP(Exsist) ϕ 1,400 42.75km — 25 MGD

S/R No.6 North		Distribution Pump Zone6	
Q(MGD)=	25	Q(m3/min)=	23.7
V(m3)=	38,000	N =	2+(1)
HWL(m)=	+ 46.0	H (m)=	40.0
LWL(m)=	+ 40.0	P (KW)=	250
GL (m)=	+ 40.0	GL (m)=	40.0

SP ϕ 800 3.5km — Distribution: Q(MGD)= 10, H.GL (m)= 45.0

SP ϕ 1,100 1km — Distribution: Q(MGD)= 15, H.GL (m)= 16.0

2MGD Hmawbi

20 Hlawga Reservoir

Intake	
Q(MGD)=	14
m3/d	63,700
HWL(m)=	+ 19.5
LWL(m)=	+ 14.3
GL (m)=	+ 20.0

Hlawga P/S

Intake		Transmission Pump	
Q(MGD)=	68	Q(m3/min)=	71.6
m3/d	309,100	N =	3+(1)
HWL(m)=	+ 19.5	H (m)=	43.0
LWL(m)=	+ 14.3	P (KW)=	800
GL (m)=	+ 20.0	GL (m)=	20.0

SP ϕ 1,600 3.25km — 50 MGD

SP(Exsist) ϕ 1,400 4 MGD

14MGD Hmawbi

Pugyi Reservoir

Intake Pump		Phugyi Intake	
Q(m3/min)=	86.0	Q(MGD)=	54
N =	2+(1)	m3/d	245,500
H (m)=	24.0	HWL(m)=	+ 35.2
P (KW)=	450	LWL(m)=	+ 27.4
GL (m)=	???	GL (m)=	+ ???

PCP ϕ 1,500

S/R No.5 Hlawga		Distribution Pump Zone5	
Q(MGD)=	50	Q(m3/min)=	28.5
V(m3)=	76,000	N =	2+(1)
HWL(m)=	+ 41.0	H (m)=	43.0
LWL(m)=	+ 35.0	P (KW)=	300
GL (m)=	+ 35.0	GL (m)=	35.0

SP ϕ 900 5km — Distribution: Q(MGD)= 12, H.GL (m)= 41.0

SP ϕ 2,000 1km — Distribution: Q(MGD)= 38, H.GL (m)= 16.0

28 MGD; SP ϕ 1,000 0.2km; 41 MGD

S/R No.7 East Dagon		Distribution Pump Zone7	
Q(MGD)=	69	Q(m3/min)=	109.0
V(m3)=	105,000	N =	3+(1)
HWL(m)=	+ 11.0	H (m)=	32.0
LWL(m)=	+ 5.0	P (KW)=	800
GL (m)=	+ 5.0	GL (m)=	5.0

SP ϕ 2,100 8km — Distribution: Q(MGD)= 69, H.GL (m)= 5.0

30 Lagunpyin Reservoir

Lagunpyin WTP		Transmission Pump	
Q(MGD)=	40	Q(m3/min)=	63.2
m3/d	181,800	N =	2+(1)
HWL(m)=	+ 11.0	H (m)=	57.0
LWL(m)=	+ 3.0	P (KW)=	800
GL (m)=	+ 5.00	GL (m)=	5.0

SP ϕ 1,200 13.4km — 40 MGD

SP ϕ 1,400 11.1km — 52 MGD

Intake		Intake Pump	
Q(MGD)=	40	Q(m3/min)=	46.4
m3/d	181,800	N =	3+(1)
HWL(m)=	+ 5.0	H (m)=	29.0
LWL(m)=	+ 0.0	P (KW)=	350
GL (m)=	+ 5.0	GL (m)=	5.0

SP ϕ 1,200 4.25km

S/R No.8 South Dagon		Distribution Pump Zone8	
Q(MGD)=	44	Q(m3/min)=	104.3
V(m3)=	69,000	N =	2+(1)
HWL(m)=	+ 11.0	H (m)=	35.0
LWL(m)=	+ 5.0	P (KW)=	800
GL (m)=	+ 5.0	GL (m)=	5.0

SP ϕ 1,700 6.5km — Distribution: Q(MGD)= 44, H.GL (m)= 8.0

9MGD Thirawa SP ϕ 700

39MGD Thanlyin,Kya SP ϕ 1,200

41 MGD SP ϕ 1,500 8.6km

Transmission Pump toNo.7	
Q(m3/min)=	64.8
N =	2+(1)
H (m)=	33.0
P (KW)=	500
GL (m)=	9.0

40 Ngamoeyeik Reservoir

Intake		Intake Pump		Nyaunghnapin WTP(I)		Transmission Pump	
Q(MGD)=	90	Q(m3/min)=	52.1	Q(MGD)=	45	Q(m3/min)=	40.6
m3/d	409,100	N =	3+(1)	m3/d	204,600	N =	7+(1)
HWL(m)=	+ 5.0	H (m)=	10.0	HWL(m)=	+ 5.0	H (m)=	98.0
LWL(m)=	+ 0.0	P (KW)=	110	LWL(m)=	+ 3.0	P (KW)=	800
GL (m)=	+ 5.0	GL (m)=	5.0	GL (m)=	+ 5.00	GL (m)=	5.0

Intake Pump		Nyaunghnapin WTP(II)	
Q(m3/min)=	52.1	Q(MGD)=	45
N =	3+(1)	m3/d	204,600
H (m)=	10.0	HWL(m)=	+ 5.0
P (KW)=	110	LWL(m)=	+ 3.0
GL (m)=	5.0	GL (m)=	+ 5.00

79 MGD PE(Ex.) ϕ 1500 +DIP ϕ 1400 18.55km

15MGD Hlaegu

4MGD

SP ϕ 2,000 4.25km

113 MGD

S/R No.4 Airport		Distribution Pump Zone4	
Q(MGD)=	72	Q(m3/min)=	52.2
V(m3)=	117,000	N =	2+(1)
HWL(m)=	+ 35.0	H (m)=	37.0
LWL(m)=	+ 29.0	P (KW)=	450
GL (m)=	+ 29.0	GL (m)=	29.0

1,200 4km — Distribution: Q(MGD)= 22, H.GL (m)= 34.0

SP ϕ 800 3.5km — Distribution: Q(MGD)= 50, H.GL (m)= 10.0

30 MGD; SP ϕ 1,000 3.55km

S/R Central No.1-2		Distribution Pump Zone1	
Q(MGD)=	30	Q(m3/min)=	47.4
V(m3)=	45,000	N =	3+(1)
HWL(m)=	+ 40.2	H (m)=	42.0
LWL(m)=	+ 35.0	P (KW)=	450
GL (m)=	+ 22.0	GL (m)=	22.0

SP ϕ 1,300 5km — Distribution: Q(MGD)= 30, H.GL (m)= 39.0

50 **Kokkowa River**

Intake		Intake Pump		Kokkowa WTP		Transmission Pump	
Q(MGD)=	60	Q(m3/min)=	69.5	Q(MGD)=	60	Q(m3/min)=	37.9
m3/d	272,700	N =	3+(1)	m3/d	272,700	N =	5+(1)
HWL(m)=	+ 5.0	H (m)=	16.0	HWL(m)=	+ 11.0	H (m)=	86.0
LWL(m)=	+ 0.0	P (KW)=	280	LWL(m)=	+ 3.0	P (KW)=	800
GL (m)=	+ 5.0	GL (m)=	5.0	GL (m)=	+ 5.0	GL (m)=	11.0

Intake		Intake Pump		Kokkowa WTP		Transmission Pump	
Q(MGD)=	60	Q(m3/min)=	69.5	Q(MGD)=	60	Q(m3/min)=	37.9
m3/d	272,700	N =	3+(1)	m3/d	272,700	N =	5+(1)
HWL(m)=	+ 5.0	H (m)=	16.0	HWL(m)=	+ 11.0	H (m)=	86.0
LWL(m)=	+ 0.0	P (KW)=	280	LWL(m)=	+ 3.0	P (KW)=	800
GL (m)=	+ 5.0	GL (m)=	5.0	GL (m)=	+ 5.0	GL (m)=	5.0

Intake		Intake Pump		Kokkowa WTP		Transmission Pump	
Q(MGD)=	120	Q(m3/min)=	69.5	Q(MGD)=	120	Q(m3/min)=	37.9
m3/d	545,400	N =	6+(1)	m3/d	545,400	N =	10+(1)
HWL(m)=	+ 5.0	H (m)=	16.0	HWL(m)=	+ 11.0	H (m)=	86.0
LWL(m)=	+ 0.0	P (KW)=	280	LWL(m)=	+ 3.0	P (KW)=	800
GL (m)=	+ 5.0	GL (m)=	5.0	GL (m)=	+ 5.0	GL (m)=	5.0

SP φ 2,000 3.65km
SP φ 2,000 3.85km
SP φ 2,000 30.5km
SP φ 2,000 28.5km
SP φ 1,600 3.55km
SP φ 1,200 0.7km
11 MGD Htantapin

60 **Toe River**

Intake		Intake Pump		Toe WTP		Transmission Pump	
Q(MGD)=	30	Q(m3/min)=	52.1	Q(MGD)=	30	Q(m3/min)=	31.6
m3/d	136,400	N =	2+(1)	m3/d	136,400	N =	3+(1)
HWL(m)=	+ 5.0	H (m)=	16.0	HWL(m)=	+ 11.0	H (m)=	97.0
LWL(m)=	+ 0.0	P (KW)=	200	LWL(m)=	+ 3.0	P (KW)=	800
GL (m)=	+ 5.0	GL (m)=	5.0	GL (m)=	+ 5.0	GL (m)=	5.0

Intake		Intake Pump		Toe WTP		Transmission Pump	
Q(MGD)=	30	Q(m3/min)=	52.1	Q(MGD)=	30	Q(m3/min)=	31.6
m3/d	136,400	N =	2+(1)	m3/d	136,400	N =	3+(1)
HWL(m)=	+ 5.0	H (m)=	16.0	HWL(m)=	+ 11.0	H (m)=	97.0
LWL(m)=	+ 0.0	P (KW)=	200	LWL(m)=	+ 3.0	P (KW)=	800
GL (m)=	+ 5.0	GL (m)=	5.0	GL (m)=	+ 5.0	GL (m)=	5.0

Intake		Intake Pump		Toe WTP		Transmission Pump	
Q(MGD)=	120	Q(m3/min)=	139.0	Q(MGD)=	120	Q(m3/min)=	47.4
m3/d	545,400	N =	3+(1)	m3/d	545,400	N =	8+(1)
HWL(m)=	+ 5.0	H (m)=	16.0	HWL(m)=	+ 11.0	H (m)=	71.0
LWL(m)=	+ 0.0	P (KW)=	500	LWL(m)=	+ 3.0	P (KW)=	800
GL (m)=	+ 5.0	GL (m)=	5.0	GL (m)=	+ 5.0	GL (m)=	5.0

SP φ 1,200 46.05km
SP φ 1,200 46.05km
SP φ 2,100 46.05km
SP φ 2000*2 5.75km
136 MGD 618,200 m3/d
68 MGD 309,100
9 MGD Twantay

SUM **645** MGD

53 MGD

S/R Kokkine No.1-1	
Q(MGD)=	53
V(m3)=	91,000
HWL(m)=	+ 42.6
LWL(m)=	+ 36.6
GL (m)=	+ 30.0

SP φ 1,400 1.2km
SP φ 2,000 2km

Distribution	
Q(MGD)=	53
H.GL (m)=	14.0

61 MGD

S/R No.2 Tamwe		Distribution Pump Zone2	
Q(MGD)=	61	Q(m3/min)=	96.4
V(m3)=	93,000	N =	3+(1)
HWL(m)=	+ 14.0	H (m)=	31.0
LWL(m)=	+ 8.0	P (KW)=	800
GL (m)=	+ 8.0	GL (m)=	8.0

SP φ 1,600 1.9km
SP φ 2,000 7km

Distribution	
Q(MGD)=	61
H.GL (m)=	8.0

67 MGD

S/R No.3 University		Distribution Pump Zone3	
Q(MGD)=	67	Q(m3/min)=	79.4
V(m3)=	102,000	N =	4+(1)
HWL(m)=	+ 23.0	H (m)=	39.0
LWL(m)=	+ 17.0	P (KW)=	800
GL (m)=	+ 17.0	GL (m)=	17.0

SP φ 2,000 5.5km

Distribution	
Q(MGD)=	67
H.GL (m)=	25.0

40 MGD

S/R No.9 Hlaing Tharyar		Distribution Pump Zone9	
Q(MGD)=	40	Q(m3/min)=	94.8
V(m3)=	61,000	N =	2+(1)
HWL(m)=	+ 11.0	H (m)=	37.0
LWL(m)=	+ 5.0	P (KW)=	800
GL (m)=	+ 5.0	GL (m)=	5.0

SP φ 1,600 9km

Distribution	
Q(MGD)=	40
H.GL (m)=	5.0

68 MGD
68 MGD

S/R No.10 Dala		Distribution Pump Zone10	
Q(MGD)=	33	Q(m3/min)=	78.2
V(m3)=	70,000	N =	2+(1)
HWL(m)=	+ 11.0	H (m)=	34.0
LWL(m)=	+ 5.0	P (KW)=	600
GL (m)=	+ 5.0	GL (m)=	5.0

SP φ 1,500 7km

Distribution	
Q(MGD)=	33
H.GL (m)=	5.0

Transmission Pump toCBD	
Q(m3/min)=	43.0
N =	5+(1)
H (m)=	71.0
P (KW)=	800
GL (m)=	5.0

Transmission Pump toCBD	
Q(m3/min)=	43.0
N =	5+(1)
H (m)=	71.0
P (KW)=	800
GL (m)=	5.0

SUM **544** MGD

SUM **544**

Table1－Calculation for New Pipeline

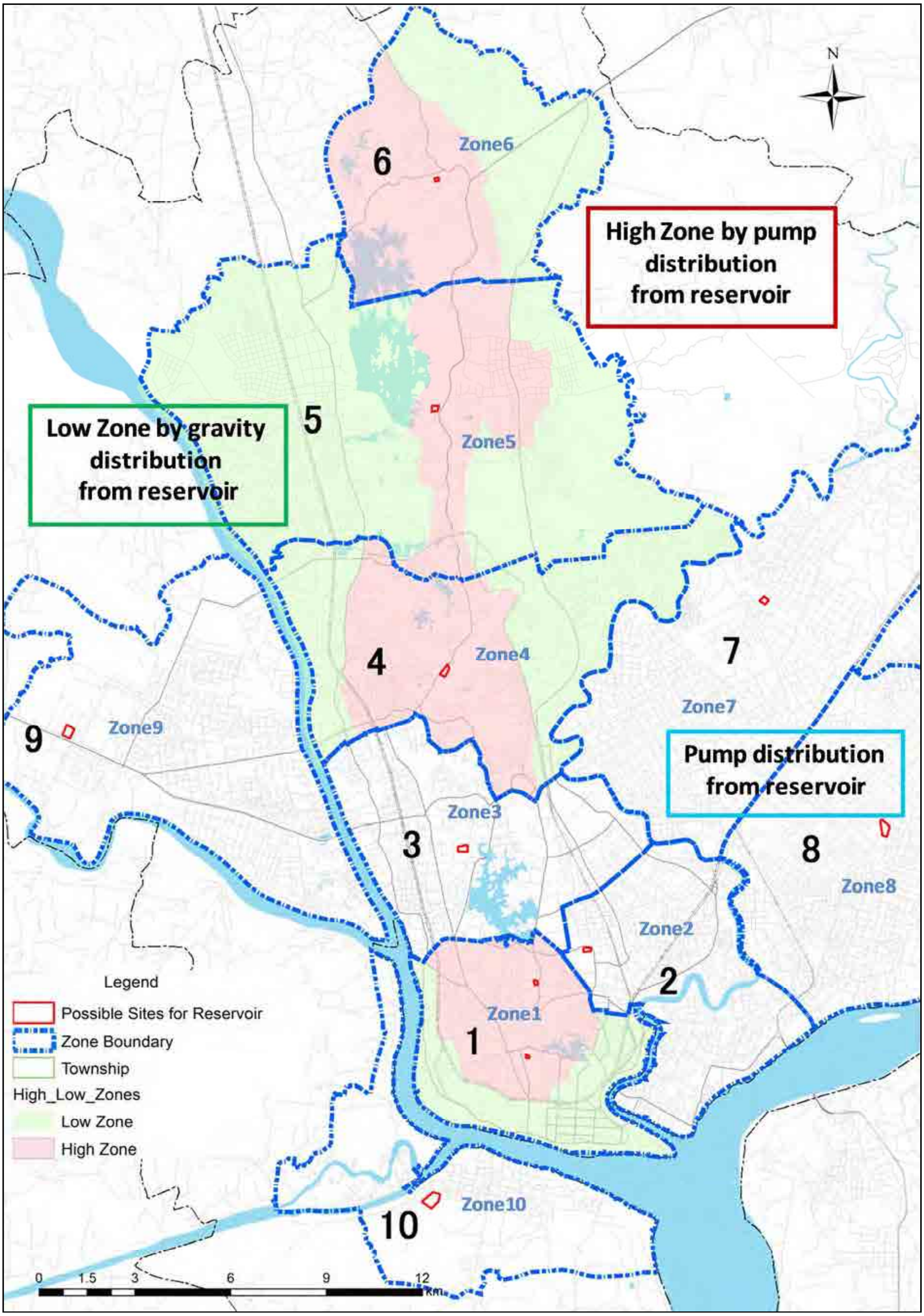
2013/4/29

Reference number	Name of Pipeline	Demand (MGD) ①	Maximum Demand (m3/D) ②	Add. Design Factor (%) ③	Calculated value (m3/D) ④	Calculated value (m3/min) ⑤	Calculated value (m3/sec) ⑥	Result of Pipeline: Diameter (mm) ⑦	Length (m) ⑧	Velocity (m/sec) ⑨	Friction Coefficient ⑩	Hydraulic Gradient (1/1,000) ⑪	Head Loss (m) ⑫	Name of Origin	LWL(m) at Origin ⑬	Dynamic Water Head (m) at Origin ⑭	Name of Destination	HWL(m) at Destination ⑮	Remaining Head (m) ⑯	Notes
10P-R	Gyobyu Transmission	27	122,800	0	122,800	85.3	1.40	1400	42,750	0.92	90	0.96	41.2	Gyobyu WTP	+51.5	+92.7	S/R No.6	+46.0	6	Exsisting MS
10P-R	Gyobyu Transmission	27	122,800	0	122,800	85.3	1.40	1000	1,300	1.81	110	3.42	4.4	Gyobyu WTP		+51.5	S/R No.6	+40.0	7	
20P-R	Hlawga Intake&Transmission	68	309,200	0	309,200	214.7	3.60	1600	3,250	1.78	110	1.91	6.2	Hlawga Int.	+14.3	+52.2	S/R No.5	+41.0	5	
30I-P	Lagunpyin Intake	40	181,900	0	181,900	126.3	2.10	1200	4,250	1.86	110	2.91	12.4	Lagunpyin Intake	+0.0	+26.4	Lagunpyin WTP	+11.0	3	
30P-R	Lagunpyin Transmission	40	181,900	0	181,900	126.3	2.10	1200	13,400	1.86	110	2.91	39.0	Lagunpyin WTP	+3.0	+55.0	S/R No.8	+11.0	5	
	Thirawa Transmission	9.2	42,000	0	42,000	29.2	0.50	700	23,200	1.26	110	2.67	62.0	S/R No.8	+3.0	+72.0	Thirawa	+5.0	5	
	Thanlyin Transmission	39	177,300	0	177,300	123.1	2.10	1200	23,200	1.81	110	2.78	64.4	S/R No.8	+3.0	+74.4	Thanlyin	+5.0	5	
42P-R	Nyaunghnapin WTP(I+II)	90	409,200	0	409,200	284.2	4.70	1889	18,550	1.69	90	2.08	38.5	Nyaunghnapin WTP(II)	+3.0	+95.4	→A	+56.9	0	Exsisting PEφ1500+DIPφ1400
	〃	121	550,100	0	550,100	382.0	6.40	2000	8,600	2.03	110	1.87	16.1	→A	+56.9	+56.9	→B	+40.8	0	
	〃	28	127,300	0	127,300	88.4	1.50	1000	200	1.88	110	3.65	0.7	→B	+40.8	+16.7	S/R No.7	+11.0	5	
	〃	52	236,400	0	236,400	164.2	2.70	1400	11,100	1.78	110	2.23	24.8	→B	+40.8	+40.8	S/R No.8	+11.0	5	
51P-R	Kokkowa Transmission(I)	40	181,900	0	181,900	126.3	2.10	1200	700	1.86	110	2.91	2.0	Kokkowa WTP	+3.0	+18.0	S/R No.9	+11.0	5	
51P-R	Kokkowa Transmission(I)	37	168,300	0	168,300	116.9	1.90	1500	30,500	1.10	110	0.85	26.0	Kokkowa WTP	+3.0	+73.6	Kokkine	+42.6	5	In 2025
52P-R	Kokkowa Transmission(II)	111	504,700	0	504,700	350.5	5.80	2000	30,500	1.86	110	1.60	48.7	Kokkowa WTP	+3.0	+83.3	→C	+34.6	0	Connection
	〃	67	304,600	0	304,600	211.5	3.50	1600	3,550	1.75	110	1.86	6.6	→C	+34.6	+34.6	S/R No.3	+23.0	5	
	Connection	10	45,500	0	45,500	31.6	0.50	2000	19,650	0.17	110	0.02	0.4	→C	+34.6	+35.4	→D	+35.0	0	
53P-R	Kokkowa Transmission(III)	129	586,500	0	586,500	407.3	6.80	2000	28,500	2.16	110	2.11	60.1	Kokkowa WTP	+3.0	+107.1	→E	+47.0	0	Connection
	〃	113	513,700	0	513,700	356.7	5.90	2000	4,250	1.89	110	1.65	7.0	→E	+47.0	+47.0	S/R No.4	+35.0	5	
60R-R	S/R No.4 Transmission	41	186,400	0	186,400	129.4	2.20	1500	13,700	1.22	110	1.03	14.1	S/R No.4	+29.0	+30.1	S/R No.7	+11.0	5	
60P-R	Toe Transmission(I)	30	136,400	0	136,400	94.7	1.60	1200	46,050	1.40	110	1.71	78.7	Toe WTP	+3.0	+94.7	S/R No.10	+11.0	5	
60P-R	Toe Transmission(II)	30	136,400	0	136,400	94.7	1.60	1200	46,050	1.40	110	1.71	78.7	Toe WTP	+3.0	+94.7	S/R No.10	+11.0	5	
60P-R	Toe Transmission(III)	120	545,600	0	545,600	378.9	6.30	2100	46,050	1.82	110	1.46	67.0	Toe WTP	+3.0	+83.0	S/R No.10	+11.0	5	
60R-R	Dala Transmission(I+II)	136	618,300	0	618,300	429.4	7.20	2603	5,750	1.34	110	0.64	3.7	S/R No.10	+5.0	+70.8	→G	+62.1	5	SPφ1700+DIPφ1700
	〃	30	136,400	0	136,400	94.7	1.60	1000	3,550	2.01	110	4.15	14.7	→G	+67.1	+59.9	Central	+40.2	5	
	〃	106	481,900	0	481,900	334.7	5.60	2000	3,850	1.78	110	1.47	5.6	→G	+67.1	+62.1	→H	+56.5	0	
	〃	114	518,300	0	518,300	359.9	6.00	2000	3,650	1.91	110	1.68	6.1	→H	+56.5	+56.5	→I	+50.4	0	
	〃	53	241,000	0	241,000	167.4	2.80	1400	1,200	1.81	110	2.31	2.8	→I	+50.4	+50.4	Kokkine	+42.6	5	
	〃	61	277,400	0	277,400	192.6	3.20	1600	1,900	1.60	110	1.57	3.0	→I	+50.4	+22.0	S/R No.2	+14.0	5	
	〃	14	63,700	0	63,700	44.2	0.70	2000	4,450	0.23	110	0.04	0.2	→I	+50.4	+47.2	→E	+47.0	0	Connection
	Zone1	30	136,400	50	204,600	142.1	2.40	1300	5,000	1.78	110	2.45	12.3	S/R Central	+35.0	+69.3	Zone1	+39.0	18	
	Zone1 by Gravity	53	241,000	50	361,500	251.0	4.20	2000	2,000	1.33	110	0.86	1.7	S/R Kokkine	+36.6	+35.0	→O	+33.3	0	
	〃	27	120,500	50	180,750	125.5	2.10	1500	2,000	1.18	110	0.97	1.9	→O	+33.3	+33.3	→P	+31.4	0	
	〃	13	60,300	50	90,450	62.8	1.00	1100	2,000	1.10	110	1.22	2.4	→P	+31.4	+31.4	Zone1	+14.0	15	
	Zone2	61	277,400	50	416,100	289.0	4.80	2000	7,000	1.53	110	1.12	7.8	S/R No.2	+8.0	+33.8	Zone2	+8.0	18	
	Zone3	67	304,600	50	456,900	317.3	5.30	2000	5,500	1.68	110	1.33	7.3	S/R No.3	+17.0	+50.3	Zone3	+25.0	18	
	Zone4	22	100,100	50	150,150	104.3	1.70	1200	4,000	1.54	110	2.04	8.2	S/R No.4	+29.0	+60.2	Zone4	+34.0	18	
	Zone4 by Gravity	50	227,300	50	340,950	236.8	3.90	2200	1,000	1.04	110	0.49	0.5	S/R No.4	+29.0	+29.6	→J	+29.1	0	
	〃	25	113,700	50	170,550	118.4	2.00	1600	3,000	0.98	110	0.64	1.9	→J	+29.1	+29.1	→K	+27.2	0	
	〃	13	56,900	50	85,350	59.3	1.00	1200	3,000	0.87	110	0.72	2.2	→K	+27.2	+27.2	Zone4	+10.0	15	
	Zone5	12	54,600	50	81,900	56.9	0.90	900	5,000	1.49	110	2.70	13.5	S/R No.5	+35.0	+72.5	Zone5	+41.0	18	
	Zone5 by Gravity	38	172,800	50	259,200	180.0	3.00	2000	1,000	0.95	110	0.47	0.5	S/R No.5	+35.0	+35.7	→L	+35.2	0	
	〃	19	86,400	50	129,600	90.0	1.50	1500	3,000	0.85	110	0.52	1.6	→L	+35.2	+35.2	→M	+33.6	0	
	〃	10	43,200	50	64,800	45.0	0.80	1100	4,000	0.79	110	0.66	2.6	→M	+33.6	+33.6	Zone5	+16.0	15	
	Zone6	10	45,500	50	68,250	47.4	0.80	800	3,500	1.57	110	3.42	12.0	S/R No.6	+40.0	+75.0	Zone6	+45.0	18	
	Zone6 by Gravity	15	68,200	50	102,300	71.0	1.20	1100	1,000	1.25	110	1.53	1.5	S/R No.6	+40.0	+39.0	→M	+37.5	0	
	〃	8	34,100	50	51,150	35.5	0.60	800	1,000	1.18	110	2.00	2.0	→M	+37.5	+37.5	→N	+35.5	0	
	〃	4	17,100	50	25,650	17.8	0.30	600	2,000	1.05	110	2.27	4.5	→N	+35.5	+35.5	Zone4	+16.0	15	
	Zone7	69	313,700	50	470,550	326.8	5.40	2100	8,000	1.57	110	1.11	8.9	S/R No.7	+5.0	+31.9	Zone7	+5.0	18	
	Zone8	44	200,100	50	300,150	208.4	3.50	1700	6,500	1.53	110	1.35	8.8	S/R No.8	+5.0	+34.8	Zone8	+8.0	18	
	Zone9	40	181,900	50	272,850	189.5	3.20	1600	9,000	1.57	110	1.52	13.7	S/R No.9	+5.0	+36.7	Zone9	+5.0	18	
	Zone10	33	150,100	50	225,150	156.4	2.60	1500	7,000	1.47	110	1.46	10.2	S/R No.10	+5.0	+33.2	Zone10	+5.0	18	

Table2 —Calculation for New Pump

Reference number	Name of Pumping Station	Demand (MGD) ①	Maximum Demand (m3/D) ②	Add. Design Factor (%) ③	Calculated value (m3/D) ④	Number of pump (Nos.) Total ⑤	Number of pump (Nos.) uding Stand ⑥	Pump Capacity (m3/min) ⑦	Result of Pumping Head: Suction Level (m) ⑧	Suction Pipe: Diameter (mm) ⑨	Suction Pipe: Length (m) ⑩	Suction Pipe: Friction Coefficient ⑪	Suction Pipe: Velocity (m/sec) ⑫	Suction Pipe: Dynamic Water Head (m) at Origin ⑬	LWL(m) at Origin ⑭	HWL(m) at Destination ⑮	Pumping Head (m) ⑯	Efficiency (%) ⑰	Margin of Electric Motor (%) ⑱	Calculated Value of Motor Output ⑲	Motor Output (KW) ⑳	Notes
10I-P	Gyoyu Intake	27	122,800	10	135,080	3	1	47.0	+39.1	700	50	90	2.04	+60.6	+42.1	+57.6	25.0	82	15	269	280	
10I-P	Phugyi Intake	54	245,500	10	270,050	3	1	93.8	+24.4	700	50	90	4.06	+38.2	+27.4	+35.2	17.0	83	15	360	400	
30I-P	Lagunpyin Intake	40	181,900	10	200,090	4	1	46.4	−2.0	700	50	110	2.01	+26.4	+0.0	+14.0	29.0	82	15	308	350	
41I-P	Nyaunghnapin WTP(I)	45	204,600	10	225,060	4	1	52.1	−2.0	800	50	110	1.73	+8.0	+0.0	+5.0	10.0	83	15	118	110	
42I-P	Nyaunghnapin WTP(II)	45	204,600	10	225,060	4	1	52.1	−2.0	800	50	110	1.73	+8.0	+0.0	+5.0	10.0	83	15	118	110	
51I-P	Kokkowa Intake (I)	60	272,800	10	300,080	4	1	69.5	−2.0	900	50	110	1.82	+14.0	+0.0	+11.0	16.0	83	15	251	280	
52I-P	Kokkowa Intake(II)	60	272,800	10	300,080	4	1	69.5	−2.0	900	50	110	1.82	+14.0	+0.0	+11.0	16.0	83	15	251	280	
53I-P	Kokkowa Intake (III)	120	545,600	10	600,160	7	1	69.5	−2.0	1200	50	110	1.02	+14.0	+0.0	+11.0	16.0	83	15	251	280	
61I-P	Toe Intake (I)	30	136,400	10	150,040	3	1	52.1	−2.0	800	50	110	1.73	+14.0	+0.0	+11.0	16.0	83	15	188	200	
62I-P	Toe Intake (II)	30	136,400	10	150,040	3	1	52.1	−2.0	800	50	110	1.73	+14.0	+0.0	+11.0	16.0	83	15	188	200	
63I-P	Toe Intake (III)	120	545,600	10	600,160	4	1	139.0	−2.0	1200	50	110	2.05	+14.0	+0.0	+11.0	16.0	84	15	496	500	
10R-D	Gyoyu Transmission	27	122,800	0	122,800	3	1	42.7	+49.5	700	20	110	1.85	+92.7	+51.5	+51.5	47.0	82	15	459	500	10I-P
20R-D	Hlawga Intake&Transmission	68	309,200	0	309,200	4	1	71.6	+12.3	900	20	110	1.88	+52.2	+14.3	+46.0	43.0	83	15	695	800	20I-P
30R-D	Lagunpyin Transmission	40	181,900	0	181,900	3	1	63.2	+1.0	900	20	110	1.66	+55.0	+3.0	+16.0	57.0	83	15	814	800	30I-P
31R-D	Thirwa Transmission	9.2	42,000	0	42,000	3	1	14.6	+1.0	400	20	110	1.94	+72.0	+3.0	+10.0	74.0	76	15	266	280	31I-P
32R-D	Thanlyin Transmission	39	177,300	0	177,300	4	1	41.1	+1.0	700	20	110	1.78	+74.4	+3.0	+10.0	77.0	82	15	723	800	32I-P
R-D	Air Transmission	41	186,400	0	186,400	3	1	64.8	+1.0	900	20	110	1.70	+30.1	+3.0	+56.9	33.0	83	15	483	500	32I-P
41R-D	Nyaunghnapin WTP	90	409,200	0	409,200	8	1	40.6	+1.0	700	20	110	1.76	+95.4	+3.0	+56.9	98.0	82	15	910	800	42I-P
51R-D	Kokkowa Transmission (I)	60	272,800	0	272,800	6	1	37.9	+1.0	700	20	110	1.64	+83.3	+3.0	+16.0	86.0	80	15	764	800	'51I-P
52R-D	Kokkowa Transmission(II)	60	272,800	0	272,800	6	1	37.9	+1.0	700	20	110	1.64	+83.3	+3.0	+34.6	86.0	80	15	764	800	'52I-P
53R-D	Kokkowa Transmission(III)	120	545,600	0	545,600	11	1	37.9	+1.0	700	20	110	1.64	+83.3	+3.0	+47.0	86.0	80	15	764	800	'53I-P
60R-D	Toe Transmission (I)	30	136,400	0	136,400	4	1	31.6	+1.0	700	20	110	1.37	+94.7	+3.0	+16.0	97.0	80	15	718	800	'60I-P
60R-D	Toe Transmission (II)	30	136,400	0	136,400	4	1	31.6	+1.0	700	20	110	1.37	+94.7	+3.0	+16.0	97.0	80	15	718	800	'60I-P
60R-D	Toe Transmission (III)	120	545,600	0	545,600	9	1	47.4	+3.0	700	20	110	2.05	+70.8	+5.0	+67.1	71.0	82	15	769	800	'60I-P
60R-R	Dala Transmission (I)	68	309,200	0	309,200	6	1	43.0	+3.0	700	20	110	1.86	+70.8	+5.0	+67.1	71.0	82	15	698	800	60R-R
60R-R	Dala Transmission (II)	68	309,200	0	309,200	6	1	43.0	+3.0	700	20	110	1.86	+70.8	+5.0	+67.1	71.0	82	15	698	800	60R-R
	Zone1	30	136,400	50	204,600	4	1	47.4	+33.0	700	20	110	2.05	+69.3	+35.0	+57.0	42.0	82	15	455	450	
	Zone2	61	277,400	50	416,100	4	1	96.4	+6.0	1000	20	110	2.05	+33.8	+8.0	+26.0	31.0	83	15	675	800	
	Zone3	67	304,600	50	456,900	5	1	79.4	+15.0	900	20	110	2.08	+50.3	+17.0	+43.0	39.0	83	15	699	800	
	Zone4	22	100,100	50	150,150	3	1	52.2	+27.0	800	20	110	1.73	+60.2	+29.0	+52.0	37.0	83	15	436	450	
	Zone5	12	54,600	50	81,900	3	1	28.5	+33.0	600	20	110	1.68	+72.5	+35.0	+59.0	43.0	78	15	295	300	
	Zone6	10	45,500	50	68,250	3	1	23.7	+38.0	500	20	110	2.01	+75.0	+40.0	+63.0	40.0	78	15	228	250	
	Zone7	69	313,700	50	470,550	4	1	109.0	+3.0	1100	20	110	1.91	+31.9	+5.0	+23.0	32.0	84	15	778	800	
	Zone8	44	200,100	50	300,150	3	1	104.3	+3.0	1100	20	110	1.83	+34.8	+5.0	+26.0	35.0	84	15	815	800	
	Zone9	40	181,900	50	272,850	3	1	94.8	+3.0	1000	20	110	2.01	+36.7	+5.0	+23.0	37.0	83	15	792	800	
	Zone10	33	150,100	50	225,150	3	1	78.2	+3.0	900	20	110	2.05	+33.2	+5.0	+23.0	34.0	83	15	600	600	

E. DESCRIPTION OF DISTRIBUTION ZONES WITH SERVICE RESERVOIR



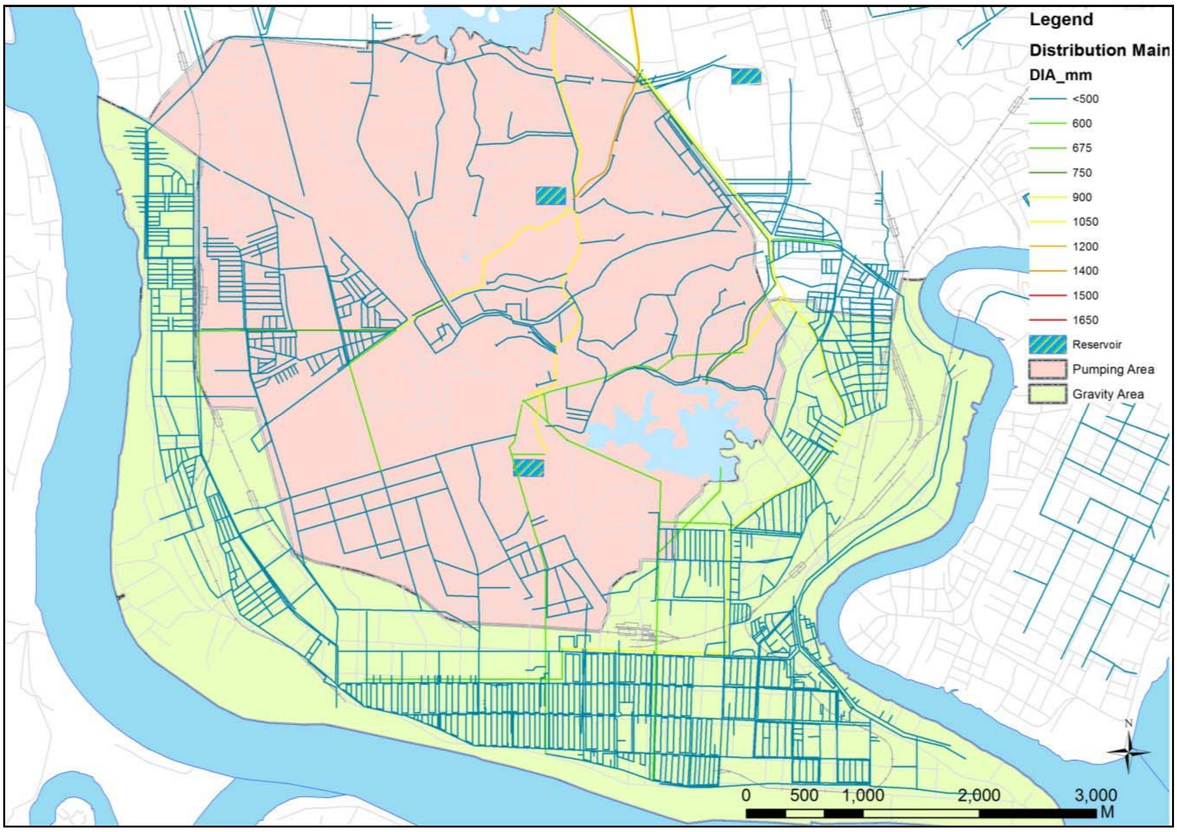
Source: JICA Study Team

Figure E.1 Distribution Zones and Proposed Service Reservoirs

Zone 1: Central area distribution zone

The natural features of Zone 1 are used efficiently. A continuous hill extends from south to north in the city, S/R is located on a high ground, and Clear water is supplied as much as possible by the gravity flow. Kokine S/R (20MG) and Shwedagon S/R (1MG) are on the hill of southern city as existing S/R. Furthermore, if Central S/R (10MG) which adjoins Shwedagon S/R is rebuilt, the total capacity of S/R will increase to 31 MG.

Zone 1 includes CBD and IUR as is shown in Figure E.2, the southernmost end of the Inya lake is the northern boundary, and Pazuntaung river is the eastern boundary. The ground level of Dagon, Bahan and Sanchaung TSs are high (about 10-20m) compared to surrounding TSs, and since they are poor water supply area, these TSs are included in the high zone and distributed by pumps. Other low elevation area is included in the low zone, and is supplied by gravity flow.



Source: JICA Study Team

Figure E.2 Outline of Distribution Zone 1

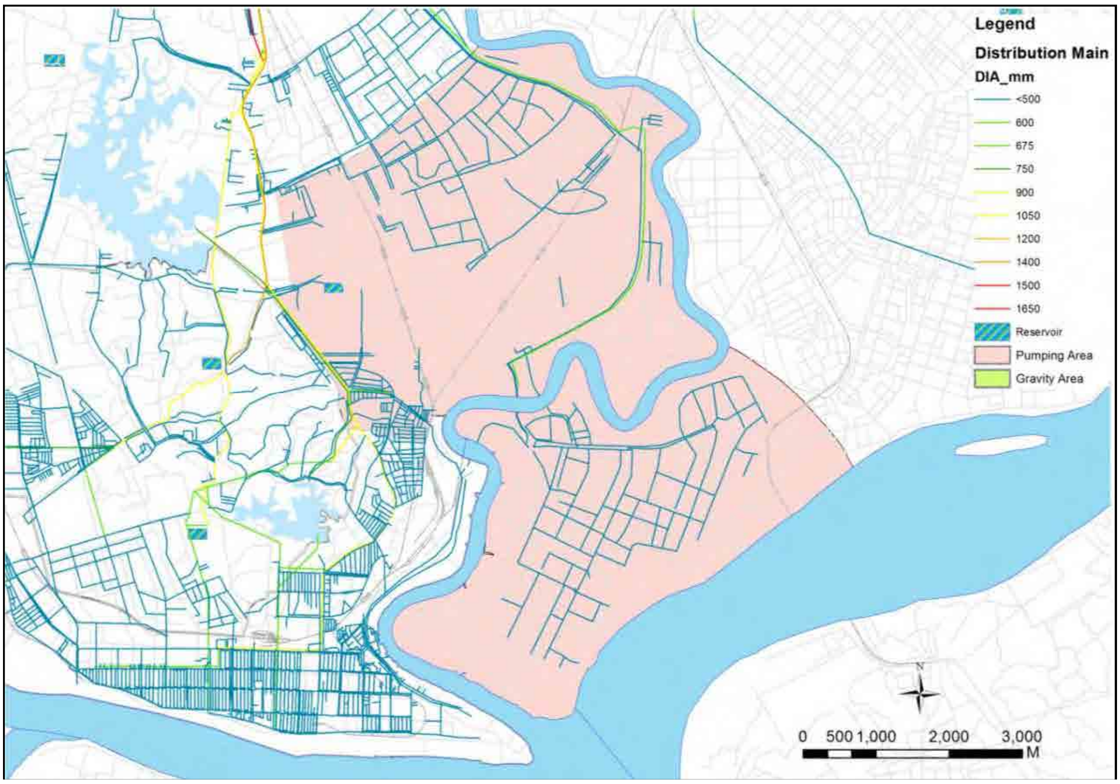
Zone 1 - Central Reservoir

Required Area - 2.1 Acre (still submitting)

Figure E.3 The Current Progress of Land Acquisition for Proposed S/R Site in Zone 1 (the End of Y2013)

Zone 2: Tarmwe, Thaketa distribution zone

Distribution Zone 2 is proposed in the east side adjoining Zone 1. In this zone, low ground elevation spreads out uniformly, and since TSs does not have a high proper place for placing S/R, water is planned to be distributed by pumps. The old racetrack having a large site is proposed for the location of S/R. Since Thaketa TS is divided by the Pazuntaung River, a plan which forms independent zone is also effective. However, since the proper place for S/R is not found in this area, Thaketa TS is included in the same distribution zone as Tarmwe.



Source: JICA Study Team

Figure E.4 Outline of Distribution Zone 2

Figure E.5 Present Land Use of Proposed S/R Site in Zone 2

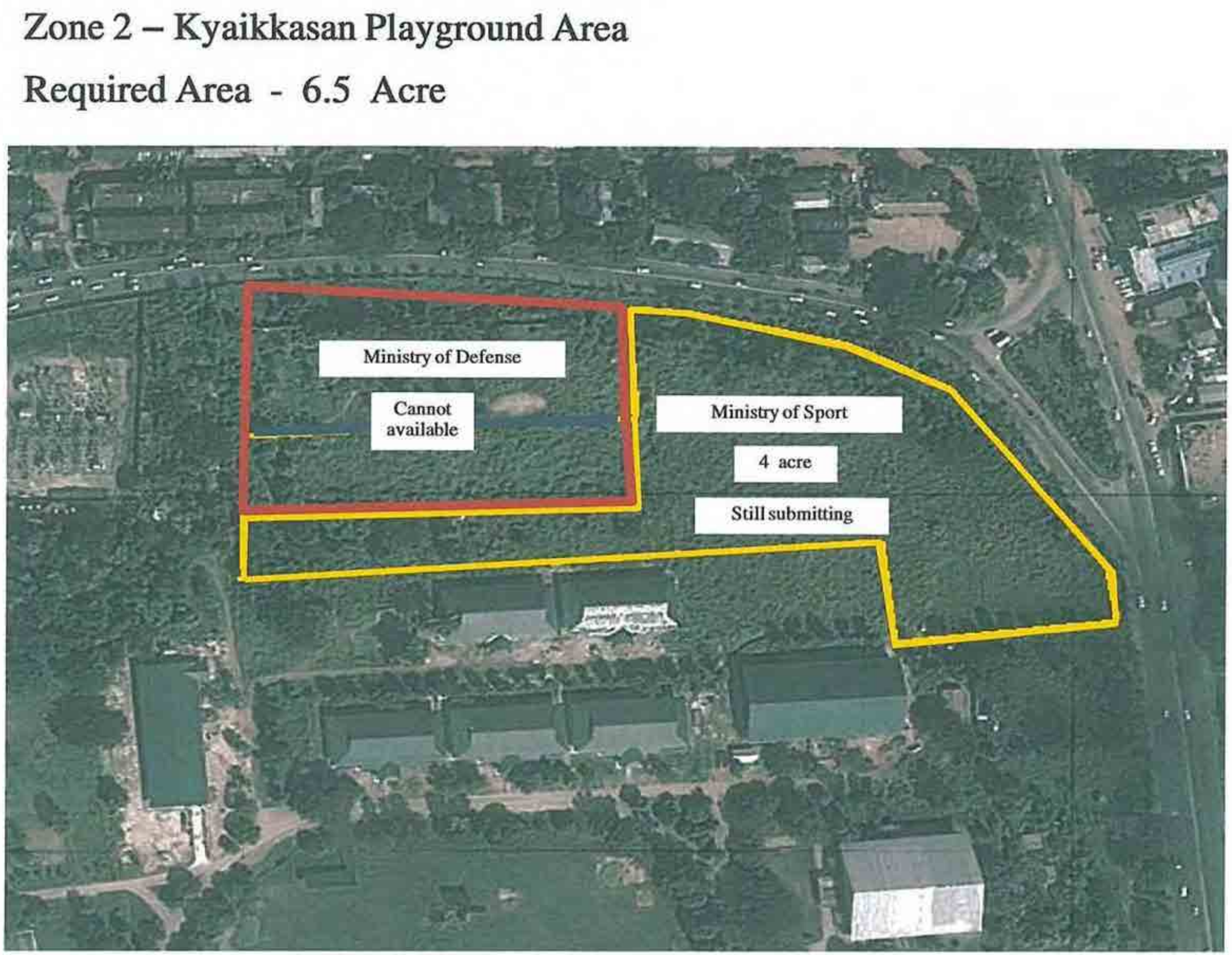
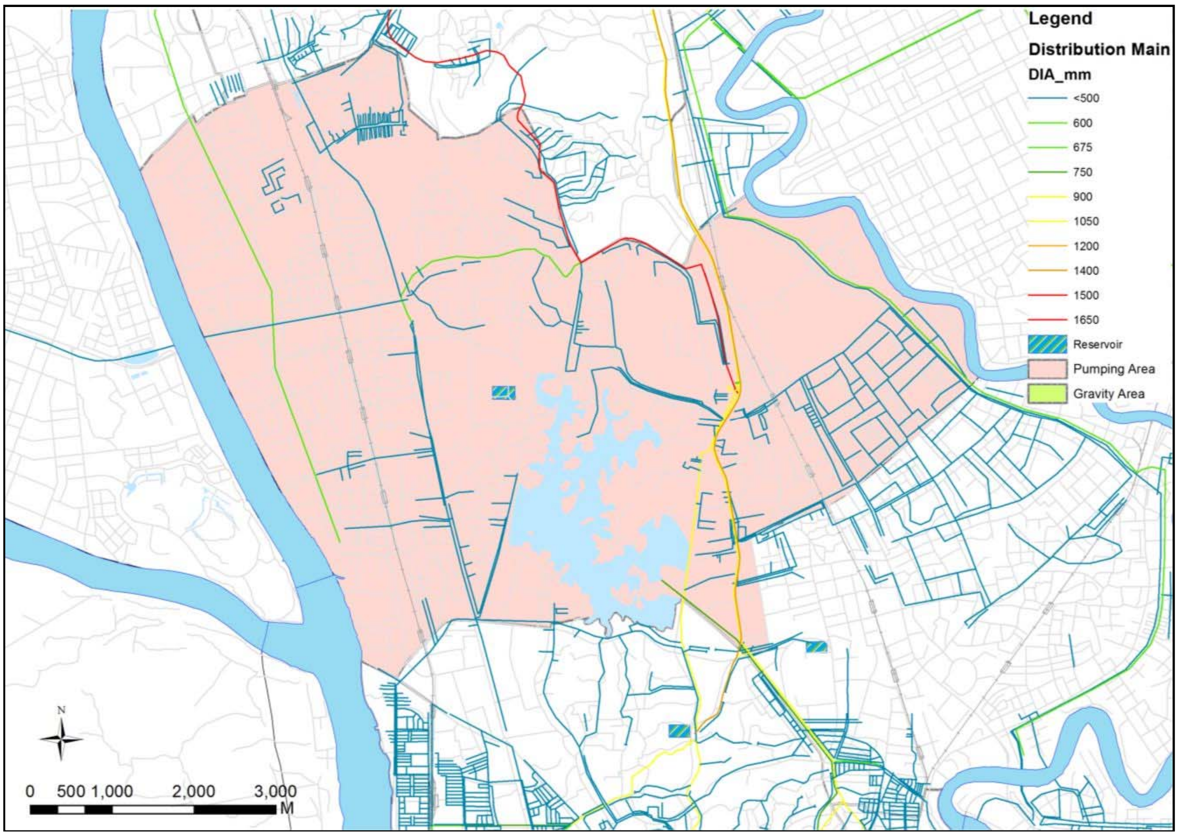


Figure E.6 The Current Progress of Land Acquisition for Proposed S/R Site in Zone 2 (the End of Y2013)

Zone 3: Hlaing distribution zone

Distribution Zone 3 is proposed in the north side adjoining Zone 1. The ground level of zone 3 is not comparatively high, the highest place is Hlaing campus in the Yangon university, and elevation is only about 20 m. Therefore, a pump supply system is adopted.



Source: JICA Study Team

Figure E.7 Outline of Distribution Zone 3

Figure E.8 Present Land Use of Proposed S/R Site in Zone 3 (Unavailable)

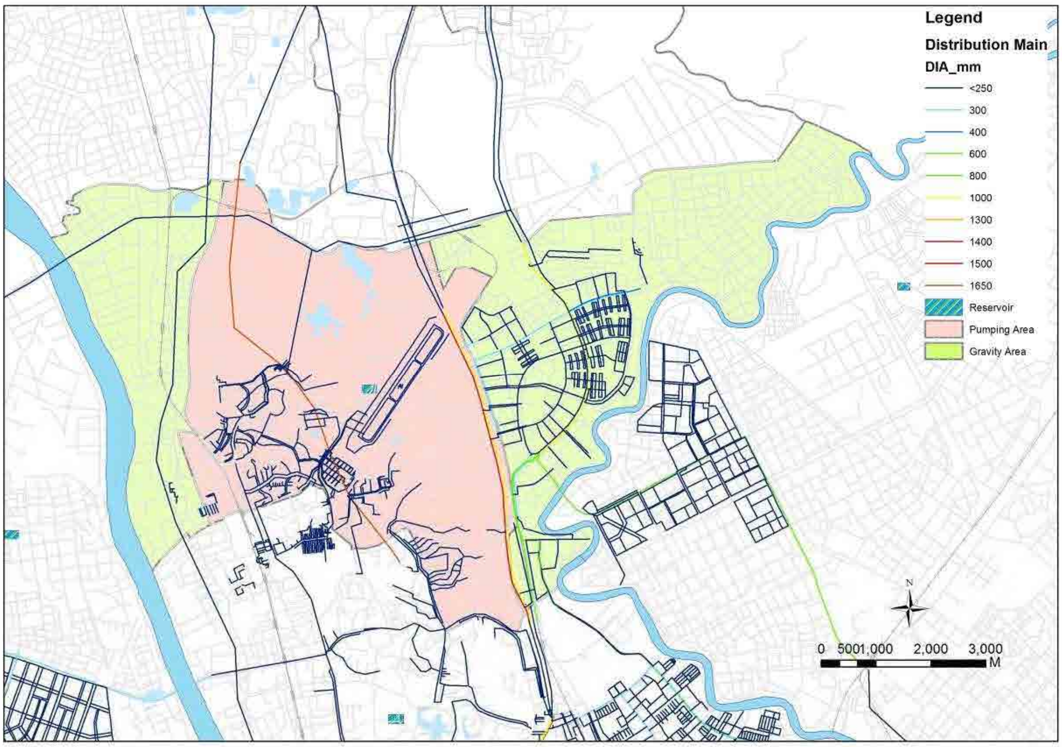
Zone 3 – Near Hlaing Campus

Required Area - 5.7 Acre (already permitted)

Figure E.9 The Current Progress of Land Acquisition for Proposed S/R Site in Zone 3 (the End of Y2013)

<u>Zone 4</u>: Mayangon distribution zone

On the north side of Zone 3, the proper place for S/R is near the Air Force headquarters located in the airport west side along the Paye road (this road runs along ridge line of the hill). The elevation of this land is about 30m. Areas along the Paye road and surroundings of the airport have high ground, and therefore is included in the high zone and is planned to be distributed by pumps. Other low ground areas is included in the low zone, and is planned to be supplied by gravity flow.



Source: JICA Study Team

Figure E.10 Outline of Distribution Zone 4

Figure E.11 Present Land Use of proposed S/R Site in Zone 4

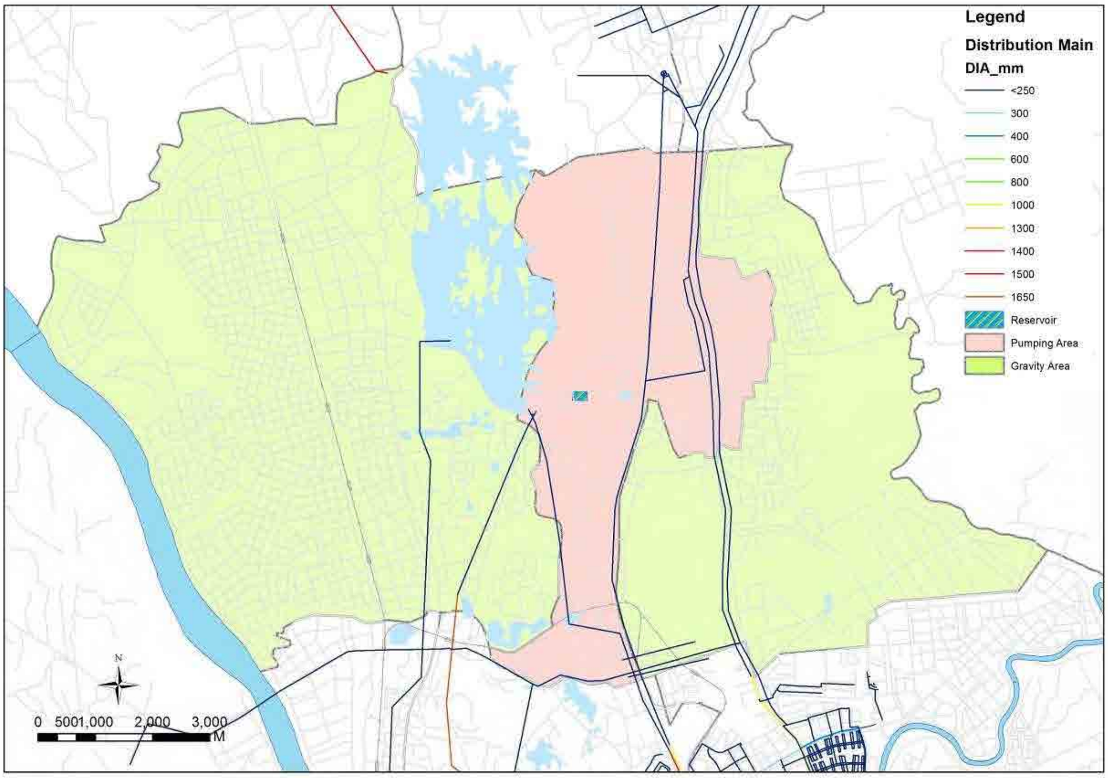
Zone 4 – Within Airport

Required Area - 6.9 Acre (still submitting)

Figure E.12 The Current Progress of Land Acquisition for Proposed S/R Site in Zone 4 (the End of Y2013)

Zone 5: Mingaladon, Shwe Pyi Thar distribution zone

On the north side of Zone 4, the ground level along the Paye road reaches 40m. In the high ground along ridge line in Zone 5 water is planned to be distributed by pumps. North Okkalapa which is eastern low ground, the northern part of Insein which is western low ground and Shwe Pyi Thar are included in the low zone, and is planned to be supplied by gravity flow.



Source: JICA Study Team

Figure E.13 Outline of Distribution Zone 5

Figure E.14 Present Land Use of Proposed S/R Site in Zone 5 (Unavailable)

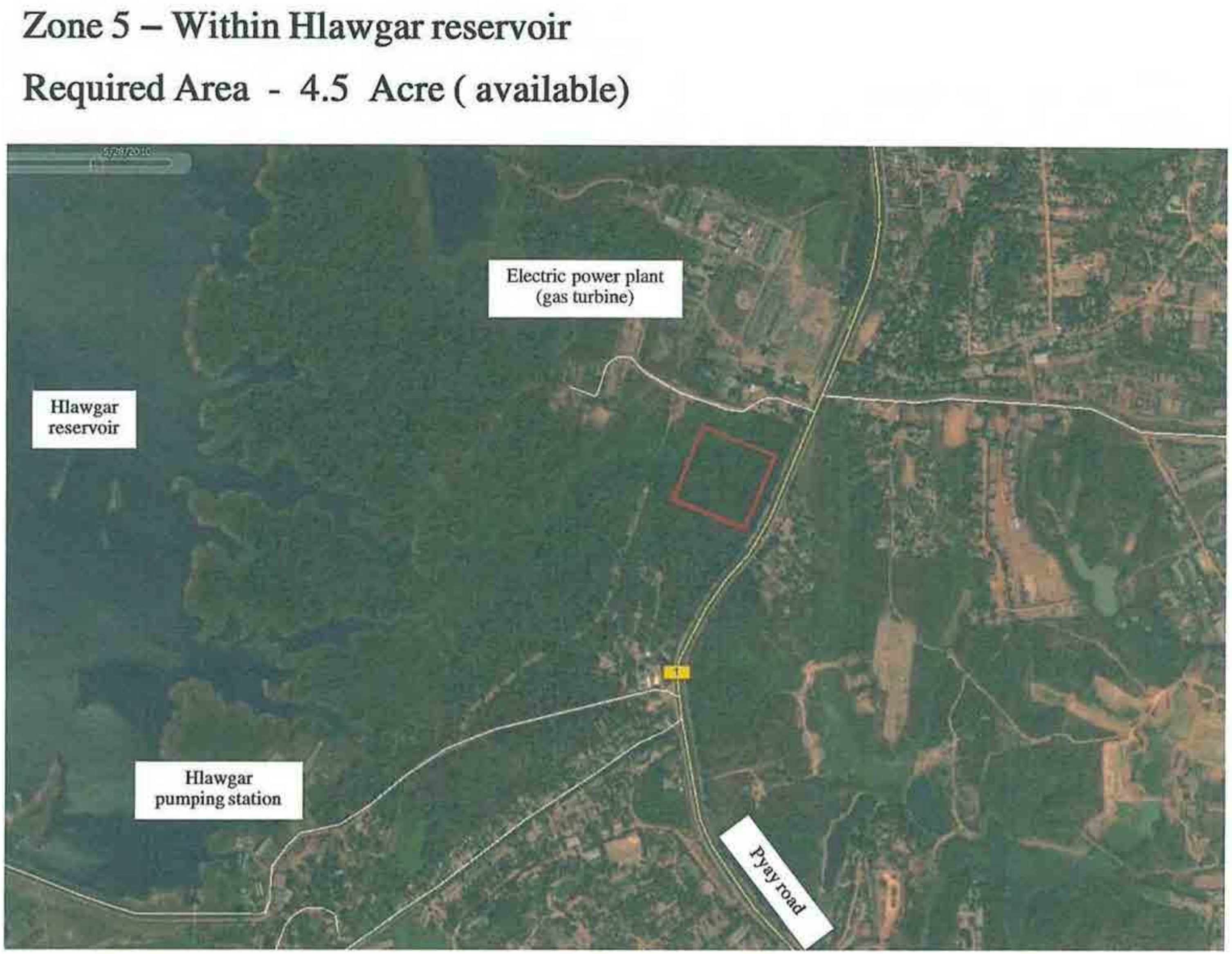
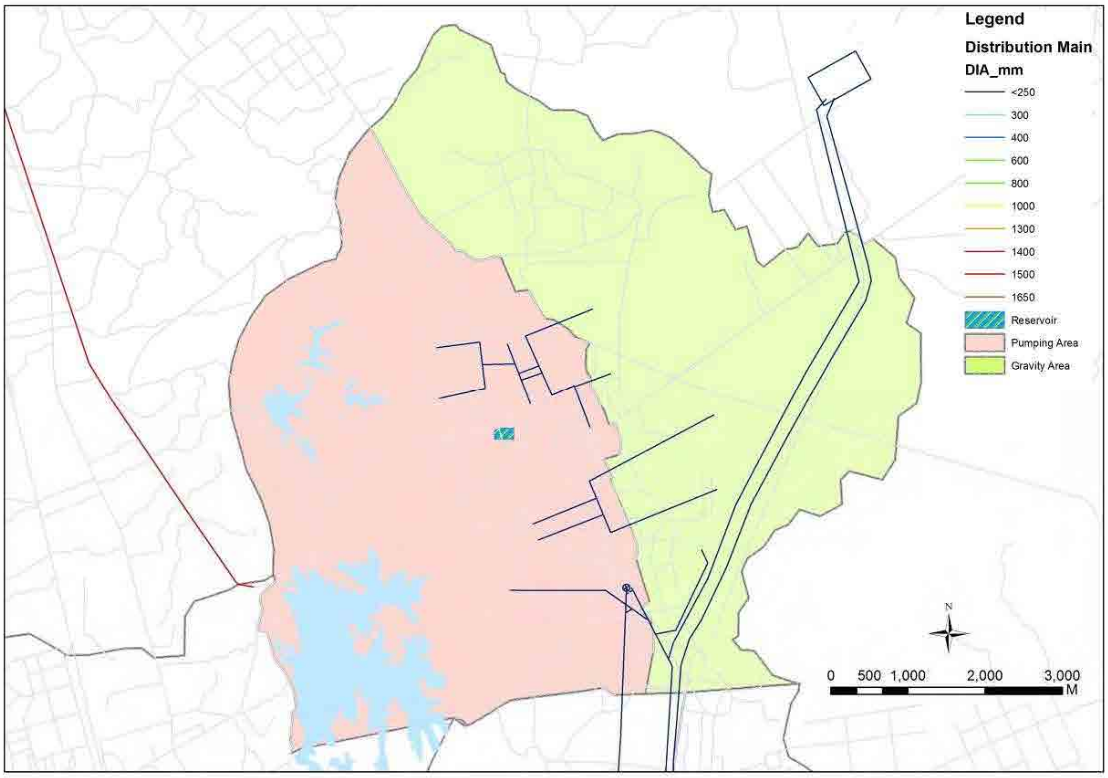


Figure E.15 The Current Progress of Land Acquisition for Proposed S/R Site in Zone 5 (the End of Y2013)

Zone 6: North side distribution zone

On the north side of Zone 5, S/R is planned to be located on the hill (ground level of 40 m) of the north side of Hlawga R. near the Taucyan. Also in Zone 6, in the high ground along ridge line water is to be distributed by pumps, Mingalardon northern part area of low ground is to be distributed by gravity flow.



Source: JICA Study Team

Figure E.16 Outline of Distribution Zone 6

Figure E.17 Present Land Use of Proposed S/R Site in Zone 6

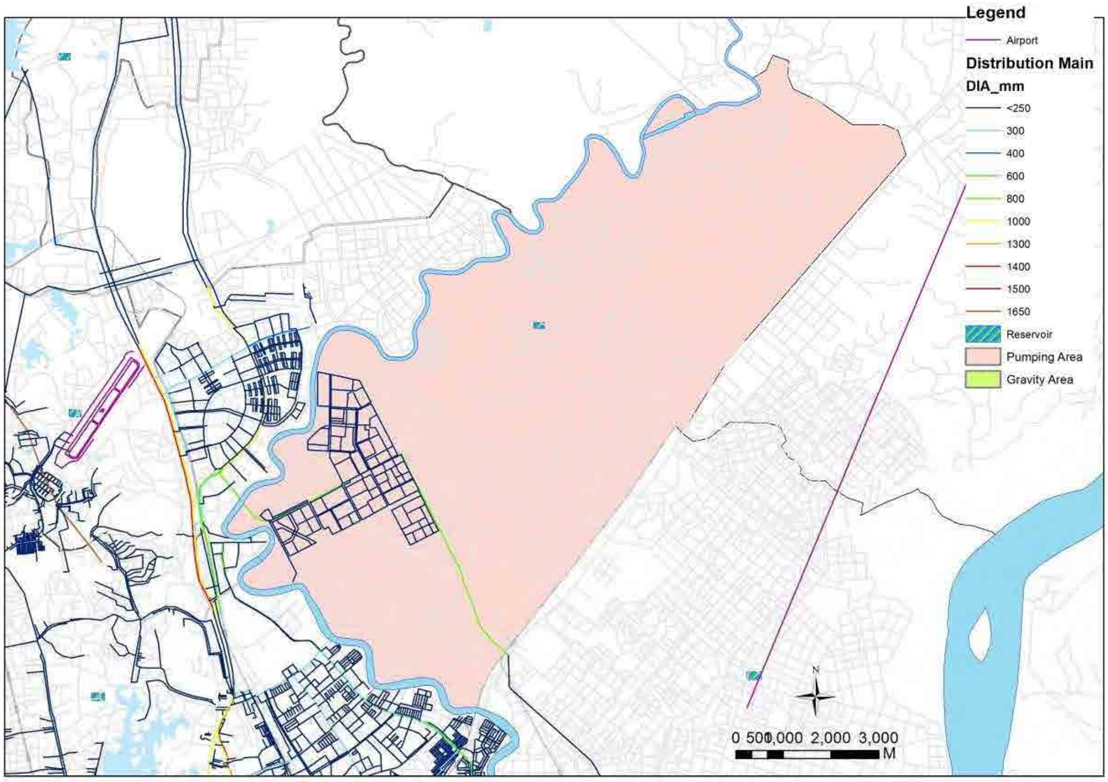
Zone 6 – Within Hlawgar reservoir (near Htauk Kyant)

Required Area - 2.5 Acre (available)

Figure E.18 The Current Progress of Land Acquisition for Proposed S/R Site in Zone 6 (the End of Y2013)

<u>Zone 7</u>: East side-1 distribution zone

East Dagon and North Dagon are included in Zone 7. In this zone, low ground spreads out uniformly, and since TSs does not have a proper high place for placing S/R, water is to be distributed by pumps. As for the location of S/R, the center of distribution zone is proposed from the viewpoint of equalizing water pressure. The following location is proposed considering satellite image and road conditions.



Source: JICA Study Team

Figure E.19 Outline of Distribution Zone 7

Figure E.20 Present Land Use of Proposed S/R Site in Zone 7 (Unavailable)

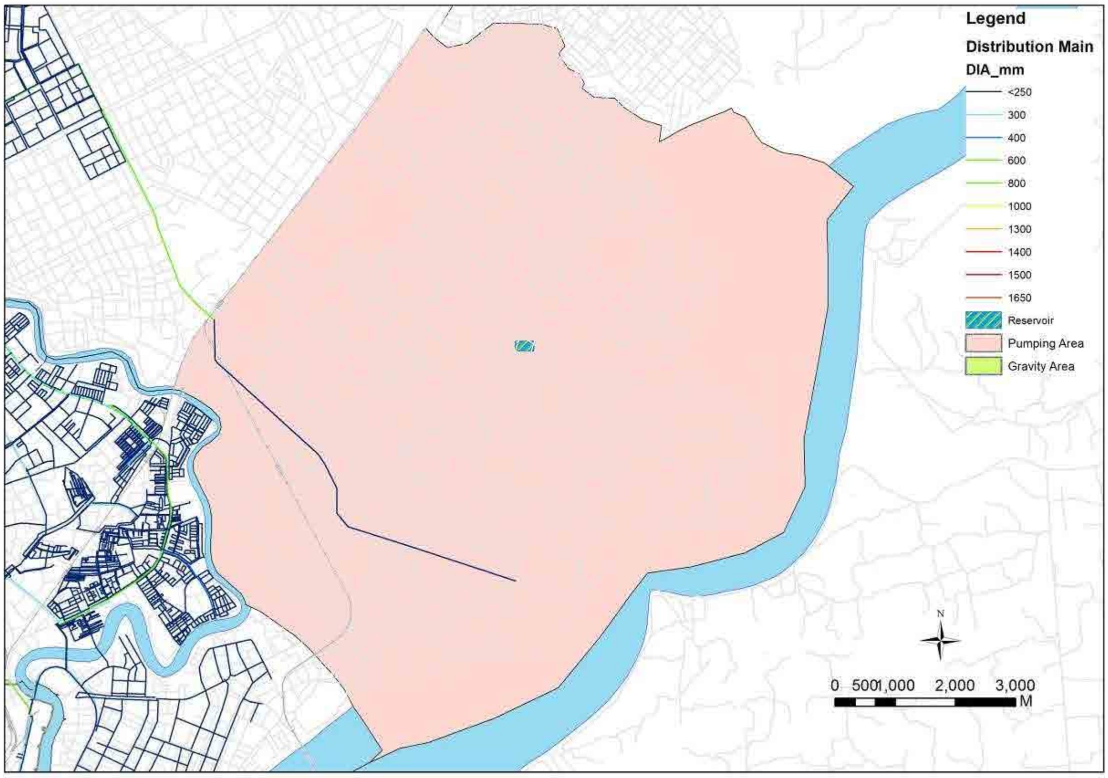
Zone 7 – Nera Dagon University (East Dagon)

Required Area - 6.1 Acre (already permitted)

Figure E.21 The Current Progress of Land Acquisition for Proposed S/R Site in Zone 7 (the End of Y2013)

Zone 8: East side-2 distribution zone

East Dagon, South Dagon, Dagon Seikkan are included in Zone 8. The reason for positioning of S/R is the same as in Zone 7.



Source: JICA Study Team

Figure E.22 Outline of Distribution Zone 8

Figure E.23 Present Land Use of Proposed S/R Site in Zone 8 (Unavailable)

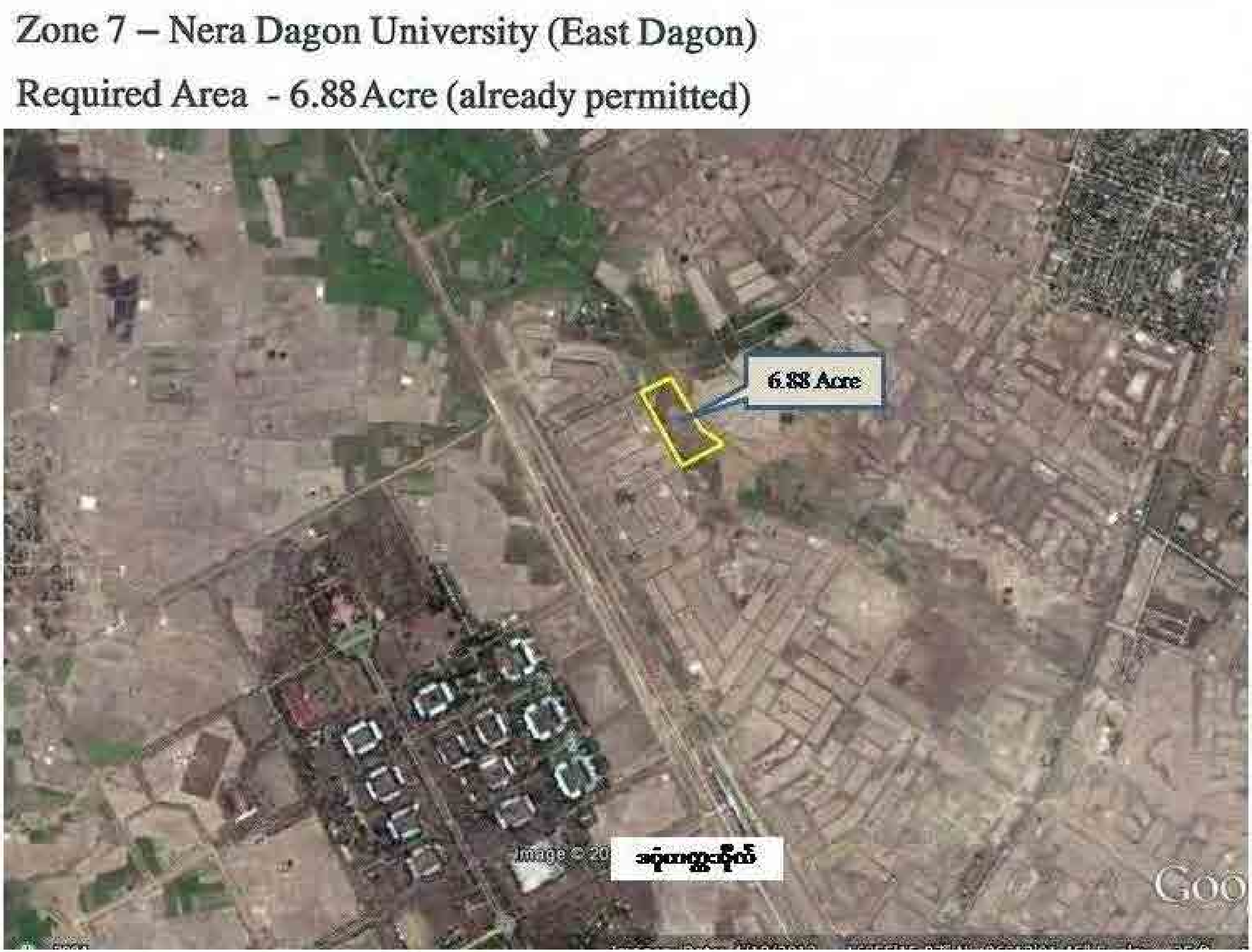
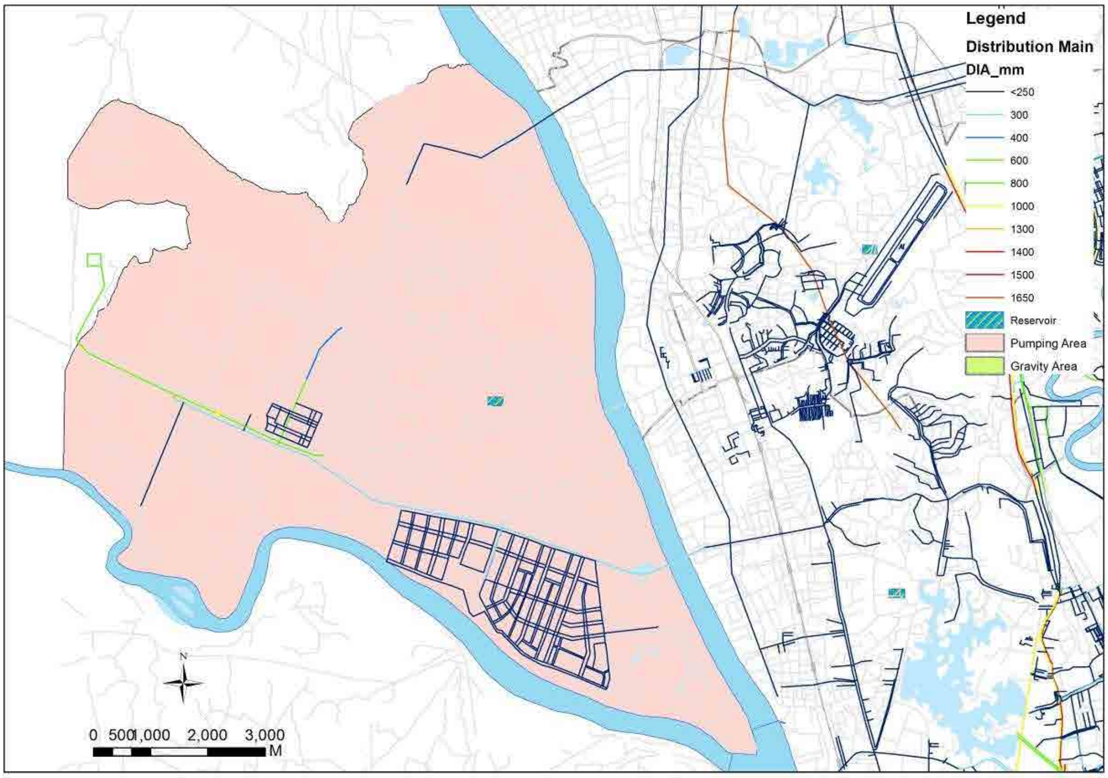


Figure E.24 The Current Progress of Land Acquisition for Proposed S/R Site in Zone 8 (The End of Y2013)

<u>Zone 9</u>: West side distribution zone

Hlaing Thar Yar is included in Zone 9. The reason for positioning of S/R is the same as in Zone 7.



Source: JICA Study Team

Figure E.25 Outline of Distribution Zone 9

Figure E.26 Present Land Use of proposed S/R site in Zone 9 (Unavailable)

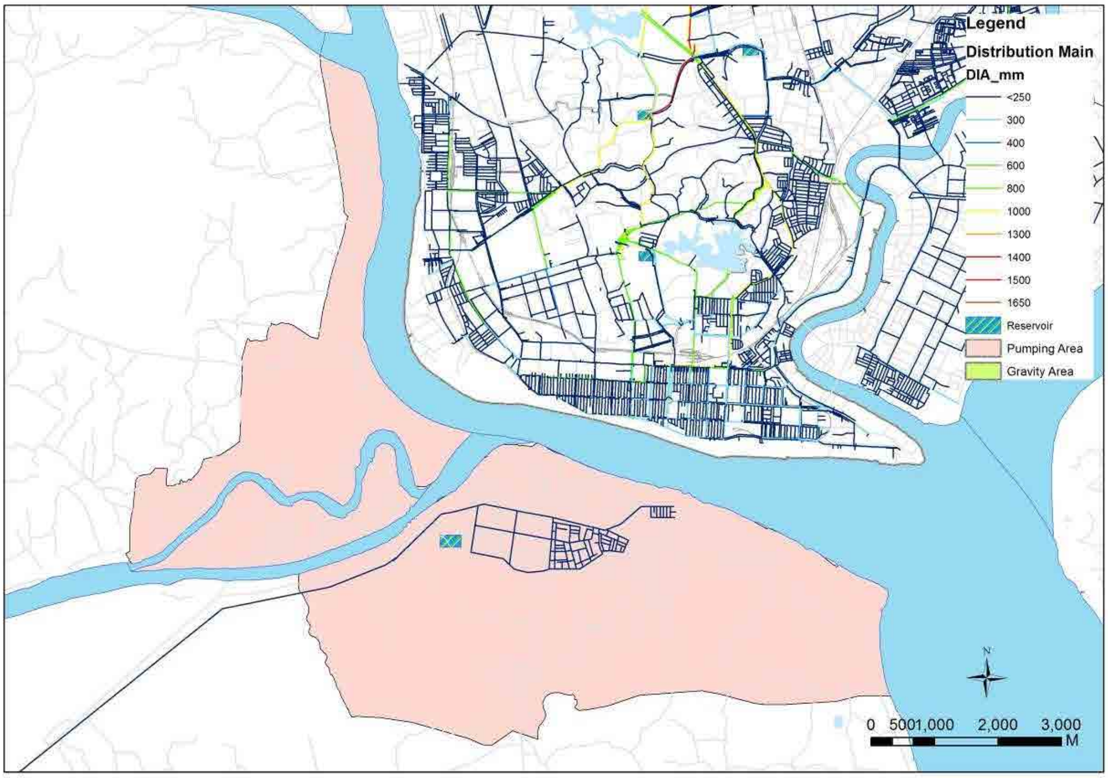
Zone 9 –Hlaing Thar Yar Township

Required Area -3.7 Acre (already permitted)

Figure E.27 The Current Progress of Land Acquisition for Proposed S/R Site in Zone 9 (The End of Y2013)

<u>Zone 10</u>: South side distribution zone

Dala, Shwe Pyi Thar, and Kyeemyindaing western parts are included in Zone 10. Although Dala and Shwe Pyi Thar are divided by the Twantay canal, they are included in one distribution zone. The reason for positioning of S/R is the same as in case of Zone 7.



Source: JICA Study Team

Figure E.28 Outline of Distribution Zone 10

Figure E.29 Present Land Use of Proposed S/R site in Zone 10

Zone 10 – Dala Township

Required Area -5.2 Acre (to purchase)

Figure E.30 The Current Progress of Land Acquisition for Proposed S/R Site in Zone 10 (the End of Y2013)

F. COST ESTIMATION OF WATERWORKS

Non-disclosure Information

Table F.1 Project Cost and Implementation Plan (1/3)

Non-disclosure Information

Table F.2 Project Cost and Implementation Plan (2/3)

Non-disclosure Information

Table F.3 Project Cost and Implementation Plan (3/3)

Non-disclosure Information

Table F.4 Operation and Maintenance Cost for Each Component (1/2)

Items	Gyobyu WTP	Hlawga PS	Phugyi PS	Lagunpyin WTP	Nyaunghnapin WTP I&II	Kokkowa I-III	Toe I-III
Salary	54,120	14,472	14,472	69,960	69,960	69,960	69,960
Electricity	432,069	658,340	438,894	731,968	1,555,522	5,322,033	3,715,151
Maintenance(Spare parts)	427,741	120,255	74,135	515,752	1,313,472	3,056,504	1,263,761
Sludge cake	0	0	0	0	0	0	0
Chemical	2,742,756	3,488,451	0	8,084,823	18,189,629	48,508,938	36,384,149
Sewer	0	0	0	0	0	0	0
Other cost	73,134	85,630	10,550	188,050	422,572	1,139,149	828,660
Total	3,729,820	4,367,148	538,050	9,590,553	21,551,154	58,096,584	42,261,682
Unit O&M cost (US$/m3)	0.033	0.016	0.002	0.058	0.058	0.059	0.057

Items	Gyobyu WTP	Hlawga PS	Phugyi PS	Lagunpyin WTP	Nyaunghnapin WTP I&II	Kokkowa I-III	Toe I-III
Salary	4.6	1.2	1.2	5.9	5.9	5.9	5.9
Electricity	36.6	55.7	37.1	62.0	131.7	450.5	314.5
Maintenance(Spare parts)	36.2	10.2	6.3	43.7	111.2	258.7	107.0
Sludge cake	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chemical	232.1	295.3	0.0	684.3	1,539.6	4,105.8	3,079.6
Sewer	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other cost	6.2	7.2	0.9	15.9	35.8	96.4	70.1
Total	316	370	46	812	1,824	4,917	3,577
Unit O&M cost (JPY/m3)	2.79	1.35	0.17	4.91	4.91	4.99	4.82

Unit of upper table: USD/Year, Unit of lower table: Million JPY/Year

Table F.5 Operation and Maintenance Cost for Each Component (2/2)

Items	Thirawa PS	Thanlyin PS	Airport PS	Dala PS	Distribution PS	DMA	Total
Salary	0	0	0	0	0	248,940	611,844
Electricity	153,361	438,894	274,398	2,194,108	4,401,865	0	20,316,604
Maintenance(Spare parts)	103,990	320,549	320,549	961,422	1,177,980	0	9,656,110
Sludge cake	0	0	0	0	0	0	0
Chemical	0	0	0	0	0	0	117,398,746
Sewer	0	0	0	0	0	0	0
Other cost	5,147	15,189	11,899	63,111	111,597	4,979	2,959,666
Total	262,499	774,632	606,847	3,218,641	5,691,442	253,919	150,942,970
Unit O&M cost (US$/m3)	0.007	0.005	0.004	0.006	0.010		0.052

Items	Thirawa PS	Thanlyin PS	Airport PS	Dala PS	Distribution PS	DMA	Total
Salary	0.0	0.0	0.0	0.0	0.0	21.1	51.7
Electricity	13.0	37.1	23.2	185.7	372.6	0.0	1,719.7
Maintenance(Spare parts)	8.8	27.1	27.1	81.4	99.7	0.0	817.4
Sludge cake	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chemical	0.0	0.0	0.0	0.0	0.0	0.0	9,936.7
Sewer	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other cost	0.4	1.3	1.0	5.3	9.4	0.4	250.3
Total	22	66	51	272	482	22	12,775.8
Unit O&M cost (JPY/m3)	0.59	0.42	0.34	0.51	0.85		4.40

Unit of upper table: USD/Year, Unit of lower table: Million JPY/Year

G. FINANCIAL EVALUATION for MASTER PLAN

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(C1 : Tariff increase 3%, 40% subsidy for capital investment)
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(C2 : Tariff increase 4%, 40% subsidy for capital investment)
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(C3 : Tariff increase 3%, 40% subsidy for capital investment)
G.12 Financial Simulation Results (D1 : Tariff increase 3%, Full cost recovery)
G.13 Financial Simulation Results (D2 : Tariff increase 4%, Full cost recovery)
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G.15 Financial Simulation Results
(E1 : Tariff increase 3%,JICA ODA Loan, 80% subsidy for initial construction costs)
G.16 Financial Simulation Results
(E2 : Tariff increase 4%,JICA ODA Loan, 80% subsidy for initial construction costs)
G.17 Financial Simulation Results
(E3 : Tariff increase 5%,JICA ODA Loan, 80% subsidy for initial construction costs)

G.1 Average Household Income

Table G.1 Average Monthly Household Income

Income classes	Number	% to Total
Below 25,000	20	0.2%
25,000 ~ 50,000	185	1.8%
50,001 ~ 75,000	434	4.3%
75,001 ~ 100,000	1,145	11.4%
100,001 ~ 150,000	2,091	20.8%
150,001 ~ 200,000	1,908	18.9%
200,001 ~ 300,000	1,890	18.8%
300,001 ~ 400,000	871	8.7%
400,001 ~ 500,000	506	5.0%
500,001 ~ 600,000	258	2.6%
600,001 ~ 700,000	124	1.2%
700,001 ~ 800,000	91	0.9%
800,001 ~ 900,000	45	0.4%
900,001 ~ 1,000,000	115	1.1%
Above 1,000,000	223	2.2%
No Answer	163	1.6%
Total	**10,069**	**100.0%**

Source: Yangon City JICA Study Team, household interview survey results

G.2 People's Willingness to Pay

People's willingness to pay amount is estimated based on the household interview survey results by the Yangon City JICA Study Team

The willingness to pay amount is estimated by using the median value of each range.

The summary result is shown as the following table.

Table G.2 Survey Results of People's Willingness to Pay

	kyat/month	Less than 500	501 ~ 1,000	1,001 ~ 2,000	2,001 ~ 3,000	3,001 ~ 5,000	5,001 ~ 7,000	More than 7,000	No Answer	**Total**
For 24 Hours' Supply Untreated water	Number	2,680	2,737	1,461	1,124	692	143	1,231	1	**10,069**
	% to Total	26.6	27.2	14.5	11.2	6.9	1.4	12.2	0	**100.0**
For 24 Hours' Supply Drinkable water	Number	2,279	2,191	1,557	1,221	1,040	264	1,516	1	**10,069**
	% to Total	22.6	21.8	15.5	12.1	10.3	2.6	15.1	0	**100.0**

Source: Yangon City JICA Study Team, household interview survey results
Estimated Average Value：2,436 Kyat/month/hh

G.3 Financial Simulation Results

(A1 : Tariff increase 3%, 100% subsidy for capital investment)

Non-disclosure Information

G.4 Financial Simulation Results

(A2 : Tariff increase 4%, 100% subsidy for capital investment)

Non-disclosure Information

G.5 Financial Simulation Results

(A3 : Tariff increase 5%, 100% subsidy for capital investment)

Non-disclosure Information

G.6 Financial Simulation Results

(B1 : Tariff increase 3%, 60% subsidy for capital investment)

Non-disclosure Information

G.7 Financial Simulation Results

(B2 : Tariff increase 4%, 60% subsidy for capital investment)

Non-disclosure Information

G.8 Financial Simulation Results

(B3 : Tariff increase 5%, 60% subsidy for capital investment)

Non-disclosure Information

G.9 Financial Simulation Results

(C1 : Tariff increase 3%, 40% subsidy for capital investment)

Non-disclosure Information

G.10 Financial Simulation Results

(C2 : Tariff increase 4%, 40% subsidy for capital investment)

Non-disclosure Information

G.11 Financial Simulation Results

(C3 : Tariff increase 3%, 40% subsidy for capital investment)

Non-disclosure Information

G.12 Financial Simulation Results

(D1 : Tariff increase 3%, Full cost recovery)

Non-disclosure Information

G.13 Financial Simulation Results

(D2 : Tariff increase 4%, Full cost recovery)

Non-disclosure Information

G.14 Financial Simulation Results

(D3 : Tariff increase 5%, Full cost recovery)

Non-disclosure Information

G.15 Financial Simulation Results

(E1 : Tariff increase 3%,JICA ODA Loan, 80% subsidy for initial construction costs)

Non-disclosure Information

G.16 Financial Simulation Results

(E2 : Tariff increase 4%,JICA ODA Loan, 80% subsidy for initial construction costs)

Non-disclosure Information

G.17 Financial Simulation Results

(E3 : Tariff increase 5%,JICA ODA Loan, 80% subsidy for initial construction costs)

Non-disclosure Information

H. MINUTES OF PUBLIC CONSULTATION SEMINAR

Minutes of Public Consultation Seminar on
The Project for the Improvement of Water Supply,
Sewerage and Drainage System in Yangon City

Venue: Ballroom, 2nd floor of Traders Hotel (Yangon)

Date: 10 April 2013 (Wednesday)

Time: 9:10 am – 13:00 pm

Attendance:

As attached.

Agenda:

1) Opening Session
2) Water Vision of Yangon City
3) Master Plan for Water Supply in Yangon City
4) Master Plan for Sewerage and Drainage in Yangon City
5) Questions and Answers
6) Closing Session

Minutes:

1. Master announced the opening of the Public Consultation Seminar on the Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City at 9:10 am.

2. Master called for Opening Speech of H. E. U Hla Myint, Mayor of Yangon City. Mayor U Hla Myint gave an opening speech.

3. Master called for Opening Remark of Mr. Masahiro Tanaka, Chief Representative of JICA Myanmar Office. Mr. Tanaka gave an opening remark.

4. Master called for the explanation of the agenda 2). Mr. Kariya of JICA Study Team made a presentation for Water Vision of Yangon City titled "Safe, Affluent & Secure Water Cycle in Future Yangon - Water Vision of Yangon City", with the introduction of seminar agendas and the explanation of study schedule at the beginning.

5. Master called for the explanation of the agenda 3) and Mr. Momose of JICA Study Team made a presentation for Master Plan for Water Supply System of Yangon titled "Master Plan for Water Supply System of Yangon" as well as the brief explanation of proposed prioritized projects for which feasibility study is currently being carried out.

6. Master called for the explanation of the agenda 4) and Mr. Miyamoto of JICA Study Team made a presentation for Master Plan for Sewerage and Drainage in Yangon City titled "Master Plan for Sewerage and Drainage System of Yangon" as well as the brief explanation of proposed prioritized projects for which feasibility study is currently being carried out.

7. Master called for questions from audience for agenda 5).
   a) Dr. Kyaw Latt made a comment to wrap up the seminar and asked for the further help to the Study Team and advice as followed.

      - ✓ The first presentation informed the audience the clear picture of future water vision in Yangon and why it is vitally important in implementing the development for Yangon City. The presentation also highlighted what will happen if sufficient measures concerning water environment are not taken as soon as possible. Then it also called for citizens' active cooperation and voluntary activities for environmental conservation with the aim to protect citizens' life and water environment. The presentation was very informative.
      - ✓ The second presentation focused on water supply system in Yangon exemplifying existing water supply conditions while reflecting severe major problems in terms of technical and financial matters. It also pinpointed a master plan to solve the existing problems and to cope with the increasing population growth in the future. It also presents some projects to be implemented on priority basis. The presentation was factual.
      - ✓ The third presentation conveyed the development scenario of wastewater treatment, priority of sewerage system development as well as sewerage tax policy. It also offered reflection on drainage master plan of Yangon with the existing condition of drainage canals, and how to improve drainage facilities for short term, mid-term, and long-term plans as well. The presentation was interesting.
      - ✓ In the presentation, the population in Yangon is expected to about 8.5 million. However, City area is expected to extend in the future and the population in the extended area is expected to reach 11 million. I think that we should keep this in mind and think about how we should supply water for the area to be extended for example.
      - ✓ In sewerage master plan, sewerage zones are determined seemingly based on township jurisdiction. I think that sewerage zones are to be determined depending on population density of the area.
      - ✓ In the sewerage presentation, improvement of the existing system and zone is proposed as the highest prioritized project. I think that the improvement of existing septic tanks must also be done at first.
      - ✓ For the development of legal system such as effluent standard from the factories to sewerage system, It is very helpful if the JICA study team can propose or show us the example of the standards or regulation laws of this kind since this kind of laws are currently being studied in the Union Government and some of them are expected to be promulgated next year.
      - ✓ I think that there should be a meeting among JICA Study Team, YCDC and universities to discuss how YCDC should do to develop water facilities such as how to improve the existing septic tanks, to which universities is conducting study and have good idea.

   b) Dr. Daw Khin Ni Ni Thein of Water, Research and Training Centre (WRTC) Myanmar made some comment and suggestions as follows:

- ✓ First, she mentioned general comments.
  1) Recently, "Sustainable Water Resources Development Standing Committee" has been established by the President's office, which is chaired by the vice President Two, U Nyan Tun.
  2) Special Economic Zone, Industrial Zones and urban areas need to share limited water resources.
  3) Climate change altered the rainfall intensity and patterns.
  4) All water projects should be met "triple bottom line", *i.e.*, (a) economically viable, (b) environmentally sustainable, and (c) socially inclusive.
  5) Water allocation, pricing and investment options should be thoroughly planned in holistic manner
  6) Based on the above mentioned points from 1) to 5), it is advisable that Yangon Water Vision should be part and parcel of the overall "Yangon City Development Plan".
- ✓ Then she made suggestions on wastewater treatment in the Sewerage Master Plan as follows:
  1) In the master plan it was mentioned how wastewater will be treated and after that it will be disposed into the river.
  2) We can use decentralized wastewater treatment system known as DEWAS, which provides clean water for domestic use except for drinking. Once wastewater is being treated, the output (clean water) can be used for gardening, cleaning, *etc*. The system is decentralized so that cost to build the central sewerage system / infrastructure can be omitted.
  3) I would like YCDC to consider using DEWAS system.
- ✓ Then she made comments on water supply as follows:
  1) On water resources development to meet the demand of increasing population with increasing water consumption per capita use, new water sources were identified. Without the holistic approach for all kinds of water usage, we will have conflicts over water allocation and use in the near future.
- ✓ Finally she made the following comments on legal system:
  1) On pricing, water quality regulation and allocation, we also need water law and regulations.
  2) Since this JICA project is a huge project, I would like to propose that H. E. Minister, Mayor of Yangon City should spearhead in supporting the "Water Law Drafting Process", which needs both financial and political support.
  3) If the Water Law is drafted with the support of JICA through the YCDC, the future implementation, monitoring and law enforcement activities would be more effective and efficient. Yangon City would also become pioneer in such systematic approach.

4) Myanmar Water Professionals are currently drafting the Myanmar Water Law for your information. That needs support.

c) Ms. Daw Than Than Soe of the Ministry of Construction made some comments and suggestions as follows:

- ✓ Implementation will be urgently required for the improvement of water supply, sewerage and drainage system.
- ✓ According to JICA Master Plan, feasibility study and design, I think the following immediate program will be seriously taken into consideration.
  1) Replacement of pumps and aging pipe to control water leakage
  2) Replacement of pumps and sewerage (existing pipe)
  3) Provision of transmission mains (about 21 miles) from Ngomoyeik Reservoir to Nyaughnapin water treatment station (at present water is raked by open channel) to improve water quality (especially with turbidity and pesticides) and to reduce cost.
- ✓ To provide safe and clean water, the improvement of water supply system must be implemented as soon as possible.
- ✓ Budget allocation from government and financial support (internal and external funding agencies) are prerequisite for the implementation and construction of water supply system.

d) In response to the above comments and questions, Mr. Momose of JICA Study Team mentioned as follows concerning water supply:

- ✓ Water supply sources are planned for the extended Yangon city, i.e., Study Area of Greater Yangon with 11.5 million populations.
- ✓ Replacement of pumps and aging pipes is proposed as a core component in each distribution zone to reduce leakage control.
- ✓ Provision of transmission mains from Ngomoyeik Reservoir to Nyaughnapin water treatment station is regarded to improve water quality with less turbidity, however, it is not planned in the Master Plan due to involving high costs. By the time above pipeline is constructed, chlorination should be done at the water treatment plants.

e) Then Mr. Miyamoto of the JICA Study Team in charge of sewerage and drainage answered as follows concerning sewerage and drainage:

- ✓ Study area for sewerage and drainage master plan covers Greater Yangon same as for water supply master plan. However, outside of current YCDC area is evaluated as low priority area for sewerage system provision except for Thilawa SEZ for which sewerage system is planned by the other study team.
- ✓ Sewerage zones have been determined based on the present and future population densities of their component townships and topography.
- ✓ Improvement of septic tanks is proposed in the master plan report. Serious disadvantage of

septic tank is the fact that this system cannot treat grey water (wastewater from kitchen, bathroom etc.) of which pollutant load is greater than black water (toilet wastewater).

- ✓ Laws and regulations which are necessary to implement and to operate sewerage system including standards for industrial wastewater are recommended in the report referring to those of Japan.
- ✓ Decentralized wastewater treatment system (DEWAS) can be one of wastewater treatment options particularly for new development areas. However, centralized sewerage is the only solution for highly urbanized area such as CBD in Yangon because there are no spaces for any on-site systems.

f) Master read out comments / questions sheet obtained from audiences.

- ✓ Comments from Dr. Khin Maunz Lwra of ADB
    1) Integrate with Myanmar Water Vision developed by Myanmar Water Partnership (MWP) based at Ministry of Agriculture & Irrigation (Department of Irrigation)
    2) Create community concern on water quality, quantity and sewerage
    3) Develop responsible behaviors from all stakeholders
    4) Build capacity for both YCDC implementers and consumers
    5) Integrate community-based or private sector capacities in this area
    6) Conduct further consultative sessions with inclusive / active participation
    7) Suggest Union Government to adopt water quality standards or integrated water quality control and management with local support
    8) Reduce the initial investment by giving partners investment and partnership plan
    9) Proposed tariffs need to be alterable in long term

- ✓ Comments and questions from Mr. Saw Christopher Maung of Yangon Technological Universities
    1) The presentation for the Water Supply, Sewerage and Drainage System (pst, present and future) is highly commendable.
    2) Do you have a plan to test the wastewater quality before designing the treatment facility?
    3) Any plan for the laboratory facilities to monitor the system, especially for water and sewerage?
- ✓ Question from Mr. Bae Hyun-sin of K-water (Korea Water Resources Corporation)
    1) Regarding to salinity of rivers, Mr. Kazufumi Momose mentioned "No salinity" during presentation. Does it mean acceptable level of salinity or zero salinity under the influence of high tide of sea?
- ✓ Comment from Ms. Khom Re of Irrigation Department
    1) From the presentation of Master Plan for Water Supply System, there are two main water sources from Kokkowa River and Toe River. In order to achieve the accuracy of

available data such as water level of Kokkowa River and Toe River, I would like to give the comment. That is to establish the automatic water level monitoring stations in Toe River and kokkowa River.

- ✓ Comment and questions from Mr. Kyaw Thak Sein of Inspection Department, YCDC
  1) Thank you for detail study for water supply and sanitation master plan of YCDC up to 2040, but you should consider the population census and upcoming revenue rates for balance budget of operations.
  2) In Master Plan of Water Supply, what is your opinions of water and sanitation revenues, which will be several times expensive than existing rate. Can it be collected from city dwellers after the project is completed?
  3) What is you experience of emergency water supply system during disasters such as earthquake, storms and drought by temperature rise?

g) In response to the above comments and questions, Mr. Momose and Mr. Miyamoto made comments and answered as follows:

- ✓ Laboratory facilities are planned in the Master Plan.
- ✓ Salinity was detected at the proposed intake site in the Toe River in the high tide period of March. Then, according to the additional survey, salinity was detected only at the proposed intake site and the Twanty canal. Salinity was not detected some kms upstream and downstream. It is considered salinity intrusion comes from Twanty canal and Yangon River and not from the Toe River itself.
- ✓ Assuming economic growth in Yangon, the proposed increased tariff is confirmed within affordable expenditure of households. However, progressive tariff system should be employed for cross-subsidy.

8. Master announced the closing of the consultation seminar the seminar adjourned at 12:20 pm.

Attachment

List of Participants

Name	Title	Organization
Regional Government Departments		
U Min Swe	Director	Irrigation Department
Daw Khon Ra	Director	Irrigation Department
U Kyi Tin	Director	Department of Development Affair
U Aye Cho	Director	Department of Human Settlement & Housing Department
Daw San San Aye	Director	Department of Human Settlement & Housing Department
Professors / Advisor		
Dr. Nyan Myint Kyaw	Professor	Civil Engineering Department, Yangon Technological University
U Than	Advisor	Yangon City Development Committee
Dr.Khin Ni Ni Thein	Chairman	Water Resource Training Centre
U Si Maung	Proffessor (Rtr)	Yangon Technological University
U Than Myint	Patron	Myanmar Engineering Society
U Parcy Lao	City Engineer (Rtr)	Myanmar Engineering Society
Dr.Khin Maung Lwin	Advisor	Asian Development Bank
Member of Parliament		
U Hla Tun	Member of Parliament	Pabadan
U Thet Tun Maung	Member of Parliament	North Okkapala
U Aye Thein	Member of Parliament	Tamwe
U Kyaw Myo	Member of Parliament	Hlaing Thar Yar
U Kyaw	Member of Parliament	Thingangyun
U Thaung Kyaw	Member of Parliament	Yankin
Dr.Saw Hla Tun	Member of Parliament	Mingalar Taung Nyunt
U Mya Ngwe	Member of Parliament	Kamaryut
Expert and Retired Government Official		
Dr.Kyaw Latt	Advisor	Yangon City Development Committee
Dr.Tun Than Tun	Head of Dept:(Rtr)	Yangon City Development Committee
U Salaing Myo Myint	Director (Rtr)	Department of Construction
Daw Than Than Soe	Director (Rtr)	Department of Human Settlement & Housing Department
Myanmar Company		
U Thant Zin	Managing Director	Han Sein Thant
U Thein Han	Managing Director	Myanmar Pipe & Accessories Co.Ltd
U Aung Myo Hein	Managing Director	Authentic Co.Ltd
U Nyi Nyi Ohn Tin	Managing Director	T & E International Co.Ltd
Col' Thaung Win	Managing Director	MMIC Co.Ltd
U Ye' Htut	Managing Director	M.Y Associates
U Tin Maung Naing	Managing Director	KOL Global Co.Ltd
Shwe Taung	Company	Shwe Taung Company
Tah Moe Nye' Chan Thar	Company	Tah Moe Nye' Chan Thar Company
Mr. Boe		K.water
Mr. Choe		K.water
Mg Kyi Kyi Myint		Shwe Taung
YCDC		
U Hla Myint	Mayor	Yangon City Development Committee
U Kyaw Soe	Secretory	Yangon City Development Committee
U Nyi Nyi	Committee Member (3)	Yangon City Development Committee

Name	Title	Organization
U Hla Aye	Committee Member (4)	Yangon City Development Committee
U Htin Zaw Win	Committee Member (5)	Yangon City Development Committee
U Soe Si	Committee Member (7)	Yangon City Development Committee
U Lin Tun Myint	Head of Dept:	Administration Department
U Myat Thet	Head of Dept:	City Planning & Land Administration Department
U Maung Maung Zaw	Head of Dept:	Engineering Department (Building)
U Myint Oo	Head of Dept:	Engineering Department(Water & Sanitation)
U Tin Maung Kyi	Head of Dept:	Engineering Department (Roads & Bridges)
U Than Lwin Oo	Head of Dept:	Pollution Control & Cleaning Department
U Ko Ko Lin	Head of Dept:	Garden Playground Parks Department
U Cho Tun Aung	Head of Dept:	Public Relations & Information Department
Dr.Myat Mon Aye	Head of Dept:	Department of Health
U Aye Kyaw Aung	Head of Dept:	Inspection Department
U Yee Win	Head of Dept:	Coordination Department
U Aung San Win	DCE	Engineering Department(Water & Sanitation)
U Kan Myint	DCE	Engineering Department(Water & Sanitation)
U Myint Thein	DCE	Pollution Control & Cleaning Department
U Kyaw Thar Sein	DCE	Inspection Department
U Toe Aung	DCE	City Planning & Land Administration Department
U Win Hlaing Tun	ACE	City Planning & Land Administration Department
U Khin Maung Phuu	ACE	Engineering Department(Water & Sanitation)
U Aung Khin Zaw	ACE	Engineering Department(Water & Sanitation)
U Myo Thein	ACE	Engineering Department(Water & Sanitation)
U Thein Min	ACE	Engineering Department(Water & Sanitation)
U Thet Lwin	ACE	Engineering Department(Water & Sanitation)
Dr. Myint Than Tun	Executive Engineer	Engineering Department(Water & Sanitation)
U Maung Maung Htay	Executive Engineer	Engineering Department(Water & Sanitation)
U Htin Lin Kha	Executive Engineer	Engineering Department(Water & Sanitation)
Daw Li Li Tin	Executive Engineer	Engineering Department(Water & Sanitation)
Daw Thwe Naing Oo	Executive Engineer	Engineering Department(Water & Sanitation)
Daw Wai Wai Myint	Executive Engineer	Engineering Department(Water & Sanitation)
Daw Khin Aye Myint	Executive Engineer	Engineering Department(Water & Sanitation)
U Nyan Thar	Executive Engineer	Engineering Department (Roads & Bridges)
U Myint Zaw Than	DCE	Y.C.D.C, Building Dept
U Tun Zaw	AE	Y.C.D.C, Building Dept
U Zar Ni	SAE	Y.C.D.C, Building Dept
U Kyaw Win Oo	SAE	Y.C.D.C, Building Dept
U Salai Wunna	SAE (YCDC)	Y.C.D.C, Building Dept
Daw Pa Pa Soe	SAE (YCDC)	Y.C.D.C, Building Dept
U Than Zaw Htay	SAE (YCDC)	Y.C.D.C, Building Dept
U Kyaw Suu Mu	SAE (YCDC)	Y.C.D.C, Building Dept
U Wunna Shwe	AE	Y.C.D.C, Building Dept
Shwe Than	AE	Y.C.D.C, Building Dept
U Hlaing Linn	AE	Y.C.D.C, Road & Bridge Dept
U Kyaw Min Oo	AE	Y.C.D.C, Road & Bridge Dept
U Myint Aye	AE	Y.C.D.C, Road & Bridge Dept
U Kyaw Ko Htet	Flat	Y.C.D.C, Road & Bridge Dept
Daw Ni Mar Zin	AE	Y.C.D.C, Water & Sanitization
U Saw Than Naing Oo		Y.C.D.C
U Khin Zan		Y.C.D.C
U Kyaw Ng Soe		Y.C.D.C
Daw The Su Nyein		DHSHD
U Lah Win	AE	Y.C.D.C
U Pyi Soe	AE	Y.C.D.C (Building Dept)

Name	Title	Organization
U Myo Kyaw	SAE	Y.C.D.C
Daw Moe Moe Khaing	SAE	Y.C.D.C (Building Dept)
Daw Htet Htet	SAE	Y.C.D.C (Building Dept)
Daw Myint Myint Sein	SAE	Y.C.D.C (Building Dept)
Daw Cho Thae Han	Flat	Y.C.D.C (Roads & Bridges)
Daw Khin Hnin Aye	EE	Y.C.D.C (PCCD)
Daw Thandar Oo	SAE	Y.C.D.C (PCCD)
U Tin Lin Tun	SAE	Y.C.D.C (PCCD)
Daw Ei Khaing Mon	AE	Y.C.D.C (W&S)
Daw Yu Yu Hla Baw	AE	Y.C.D.C (W&S)
U Myo Thant Tun	SAE	Y.C.D.C (W&S)
U Hla Myint	AE	Y.C.D.C (Road & Bridge)
U Mg Mg Thein	AE	Y.C.D.C (Road & Bridge)
U Soe Tint	AE	Y.C.D.C (Road & Bridge)
U Than Htay	AE	Y.C.D.C (Road & Bridge)
U Win Htay	AE	Y.C.D.C (Road & Bridge)
U Nay Kyi Oo	AE	Y.C.D.C (Road & Bridge)
U Saw Naing	SAE	Y.C.D.C (Road & Bridge)
U Pyae Sone	SAE	Y.C.D.C (Road & Bridge)
U Moe Htein Linn	AE	Y.C.D.C (Road & Bridge)
U Mg Mg Kyi	SAE	Y.C.D.C (Road & Bridge)
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Yee Mon Win+2		MRTV
Khin Nyein Chan Aung+	Reporter	MRTV - 4
		MITV
Pyae Phyo Kyaw	Reporter	Sky Net
		City News
Aung Myo Kyaw		MWD
		Weekly Eleven
		Snap Shot
		Yangon Time
		Popular News
		Myanmar Times
		NHK-BKK
		Pyi Myanmar
Pyae Phyo Aung	Reporter	The Voice
Moe Myint Kyaw	Reporter	Myit Makha Media
Su Pyae Soan Oo	Reporter	Myit Makha Media
Soe Tun Thein	Reporter	MNTV
Lai Lai Thin	Producer	MRTV
Ye Htut Oo	Camera	MRTV
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Masaru MATSUOKAT		JICA Expert
Hideyuki Wakasa	Team Leader	Project for Thilawar Infrastructure
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RobertHiiro Mikami		Japan Architectural Laboratory Co.,Ltd.
Yoshimitsu Yamada	Yangon Office	Fukken
Akasaki	Yangon Office	Fukken
HONDA Megumi	Infrastructure Projects Div	Mitsui & Co.(Asia Pacific) Pte.Ltd.
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Ma Yin Nyein Mon		Kubota Corp
Yukihiro Iwasaki	DGM,Yangon Branch	Mitsubishi Coporation
Shwe Sin Than	Yangon Branch	Mitsubishi Coporation
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Ma Myat Mon Yee	Sales Engineer	Smart Engineering
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Nobuya NAKADA	General Manager	Nippon Express
Wint Wah Maung	Sales Executive	Sojitz Corporation
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Quentin Deroo		Embassy of France
PARK, KEONSOO	First Secretary	Embassy of the Republic of KOREA
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Shoko Yamada	Environmental and Social Considerations	JICA Study Team
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May Thae Phyu	Assistant	JICA Study Team
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